UNIVERSIDADE FEDERAL DE MINAS GERAIS

INSTITUTO DE CIÊNCIAS AGRÁRIAS

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS FLORESTAIS

Eliane Favalessa Zarzenon Nunes

APRENDIZAGEM BASEADA EM PROBLEMAS EM DISCIPLINAS DO CURSO DE GRADUAÇÃO EM ENGENHARIA FLORESTAL

Montes Claros

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Dissertação apresentada ao Programa de Pós-graduação em Ciências Florestais da Universidade Federal de Minas Gerais, como requisito parcial à obtenção do título de Mestre em Ciências Florestais.

Orientador: Prof. Dr. Pedro Guilherme Lemes Alves

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ATA DE DEFESA DE DISSERTAÇÃO

Aos dezenove dias do mês de janeiro do ano de dois mil e vinte e seis, às 8:00 horas, sob a Presidência do Professor Pedro Guilherme Lemes Alves, D. Sc. (Orientador – UFMG/ICA) e com a participação dos Professores Giovanni Campos Fonseca, D. Sc. (UFMG/ICA) e Luiza de Almeida Lucena, D. Sc. (University of Minnesota), reuniu-se, no por videoconferência, a Banca de Defesa de Dissertação de **Eliane Favalessa Zarzenon Nunes**, aluna do Curso de Mestrado em Ciências Florestais. Após a avaliação da referida aluna, a Banca Examinadora procedeu à publicação do resultado da defesa da Dissertação intitulada: **"APRENDIZAGEM BASEADA EM PROBLEMAS EM DISCIPLINAS DO CURSO DE GRADUAÇÃO EM ENGENHARIA FLORESTAL"**, sendo a aluna considerada **APROVADA**. E, para constar, eu, Professor Pedro Guilherme Lemes Alves, Presidente da Banca, lavrei a presente ata que depois de lida e aprovada, será assinada por mim e pelos demais membros da Banca examinadora.

Obs.: A aluna somente receberá o título após cumprir as exigências do ARTIGO 74 do regulamento do Curso de Mestrado em Ciências Florestais, conforme apresentado a seguir:

Art. 74 – Para dar andamento ao processo de efetivação do grau obtido, o candidato deverá, após a aprovação de sua Dissertação e da realização das modificações propostas pela banca examinadora, se houver, encaminhar à secretaria do colegiado do Curso, com a anuência do orientador, no mínimo 3 (três) exemplares impressos e 1 (um) exemplar eletrônico da dissertação, no prazo de 60 (sessenta) dias.

Montes Claros, 19 de janeiro de 2025.

Assinatura dos membros presentes da banca:

Giovanni Campos Fonseca (Membro)

Luiza de Almeida Lucena (Membro)

Pedro Guilherme Lemes Alves (Orientador)

Ciências Florestais

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RESUMO

A Aprendizagem Baseada em Problemas (ABP), ou *Problem Based Learnig* (PBL) em inglês é adotada no ensino superior pois desenvolve nos alunos competências técnicas e socioemocionais como criatividade, comunicação, trabalho em equipe e resolução de problemas. Apesar de ser adotada em diversas áreas do conhecimento, ainda é pouco aplicada nas Ciências Agrárias. Com o objetivo de compreender como a PBL tem sido recebida por alunos da graduação de Engenharia Florestal, esta pesquisa avaliou a satisfação discente ao longo de quatro anos nas disciplinas de Entomologia Florestal e de Apicultura oferecidas na Universidade Federal de Minas Gerais. O estudo envolveu a aplicação de um questionário para avaliar a satisfação dos estudantes, suas percepções e a intenção de continuar usando a metodologia. No total, foram analisados 68 questionários da disciplina de Entomologia Florestal e 137 da disciplina de Apicultura. A relação entre os dados demográficos e as respostas também foi avaliada. A PBL recebeu uma alta aceitação em ambas as disciplinas. Em Entomologia Florestal, os estudantes relataram que a metodologia contribuiu para o desenvolvimento de habilidades profissionais e interpessoais, destacando trabalho em equipe e resolução de problemas, além de favorecer maior engajamento. Alunos com alta autoestima apresentaram percepções mais positivas sobre cooperação e maior autoconfiança para resolver problemas, em comparação aos de autoestima média ou baixa. Na disciplina de Apicultura, a maioria dos alunos também expressou satisfação com a PBL, embora muitos tenham apontado que o trabalho em grupo foi um desafio da metodologia. Os estudantes de Apicultura com alta autoestima relataram sentir-se mais confiantes para resolver problemas reais depois das sessões, mais estimulados a fornecer e receber *feedback* e, de modo geral, demonstraram gostar mais da PBL do que aqueles com autoestima média ou baixa. De maneira geral, os estudantes dessas disciplinas acreditam que a PBL promoveu a aprendizagem ativa e desenvolveu competências importantes na formação de Engenheiros Florestais, embora desafios como a dinâmica de grupos e a necessidade de maior autonomia ainda sejam percebidos. A elevada satisfação discente observada ao longo do período analisado, aliada às percepções positivas sobre a abordagem, reforçam o potencial da PBL como uma metodologia promissora para a formação em Engenharia Florestal. Os resultados evidenciam que a satisfação dos estudantes é influenciada por múltiplos fatores, como a qualidade e a estrutura dos problemas propostos, o período de formação acadêmica e aspectos demográficos e psicológicos. Assim, a implementação da PBL não deve seguir um modelo único, mas requer ajustes contínuos, acompanhamento tutorial e adaptação às especificidades e aos diferentes perfis das turmas para que seu potencial formativo seja alcançado.

Palavras-chave: ciência florestal; desenvolvimento profissional; ensino superior; resultados de aprendizagem; *soft skills*.

ABSTRACT

Problem-Based Learning (PBL) has been adopted in higher education because it fosters the development of technical and socio-emotional competencies, such as creativity, communication, teamwork, and problem-solving. Although it is used in several fields of knowledge, its application in the Agricultural Sciences remains limited. In order to understand how PBL has been received by Forestry Engineering students, this study evaluated student satisfaction over a four-year period in the courses of Forest Entomology and Apiculture offered at the Federal University of Minas Gerais. The study involved the administration of a questionnaire to assess students' satisfaction, perceptions, and intention to continue using the methodology. In total, were analyzed 68 questionnaires from the Forest Entomology course and 137 from the Apiculture course. The relationship between demographic data and students' responses was also examined. PBL received high acceptance in both courses. In Forest Entomology, students reported that the methodology contributed to the development of professional and interpersonal skills, particularly teamwork and problem-solving, in addition to fostering greater engagement. Students with high self-esteem showed more positive perceptions of cooperation and greater self-confidence in solving problems compared to those with moderate or low self-esteem. In the Apiculture course, most students also expressed satisfaction with PBL, although many identified group work as a challenge of the methodology. Apiculture students with high self-esteem reported feeling more confident in solving real-world problems after the sessions, more encouraged to give and receive feedback, and, overall, demonstrated greater appreciation for PBL than those with moderate or low self-esteem. Overall, students in both courses believed that PBL promoted active learning and developed competencies that are important for the education of Forestry Engineers, although challenges such as group dynamics and the need for greater autonomy were still perceived. The high level of student satisfaction observed throughout the analyzed period, together with the positive perceptions of the approach, reinforces the potential of PBL as a promising methodology for Forestry Engineering education. The results indicate that student satisfaction is influenced by multiple factors, including the quality and structure of the proposed problems, the stage of academic training, and demographic and psychological aspects. Therefore, the implementation of PBL should not follow a one-size-fits-all model, but rather requires continuous adjustments, close tutorial support, and adaptation to the specific characteristics and diverse profiles of student groups in order to fully realize its educational potential.

Keywords: forest science; higher education; learning outcomes; professional development; soft skills.

LISTA DE TABELAS

LISTA DE ABREVIATURAS E SIGLAS

ABP – Aprendizagem baseada em problemas

ELT – Teoria de aprendizagem experiencial

PBL – *Problem based learning*

PjBL – *Project based learning*

TBL – *Team based learning*

SUMÁRIO

CAPÍTULO 1 – CONTEXTUALIZAÇÃO, PROBLEMA DE PESQUISA E OBJETIVOS

1.1 INTRODUÇÃO

Tecnologias como inteligência artificial, *big data*, computação em nuvem e realidade virtual têm transformado a sociedade e a economia, afetando pessoas e organizações (Poláková *et al.*, 2023). O avanço tecnológico impulsiona a automação de tarefas, reduz a dependência do trabalho manual em atividades rotineiras e redireciona recursos humanos para funções que exigem competências de maior valor agregado (Babashahi *et al*., 2024). Como consequência, surgem novas funções e cargos que exigem *soft skills* e uma postura de aprendizagem autodirigida (Horváthová; Hrnčiar; Rievajová, 2022).

As *soft skills* englobam um conjunto de habilidades, atitudes, hábitos e traços de personalidade, como por exemplo trabalho em equipe, pensamento crítico, criatividade, resolução de problemas e comunicação efetiva, que favorecem o desempenho profissional (Kubátová *et al*., 2025). Elas complementam as competências técnicas e influenciam a forma como as pessoas se relacionam no ambiente de trabalho (Huerta; Santamargarita; Pérez, 2024). No contexto do mercado de trabalho do século XXI, o desenvolvimento de *soft skills* torna-se ainda mais relevante diante do avanço da Indústria 4.0, caracterizada pela integração de sistemas ciber-físicos, inteligência artificial, análise de *big data*, computação em nuvem, internet das coisas e tecnologias *blockchain*. À medida que a transformação digital se intensifica, as organizações passam a reconhecer essas competências como elementos centrais para a promoção da inovação, do trabalho colaborativo e da capacidade adaptativa em ambientes tecnologicamente disruptivos (Poláková *et al*., 2023).

A organização curricular no ensino universitário baseada, em grande parte, em aulas expositivas, tem sido debatida. Modelos expositivos de aulas podem não atender às necessidades da sociedade, que espera dos futuros profissionais a capacidade de lidar com os desafios relacionados à sustentabilidade e ao avanço tecnológico (Sukackė *et al*., 2022). O estudante deve ser capaz de criar soluções e antecipar demandas, desenvolvendo habilidades como pensamento crítico, criatividade, comunicação eficaz, colaboração e autonomia, além de competências socioemocionais como resiliência e autorregulação (Sukackė *et al*., 2022).

De acordo com o relatório *The Future of Jobs Report 2025* (Relatório sobre o Futuro dos Empregos), do Fórum Econômico Mundial, habilidades como pensamento criativo, escuta ativa, empatia, resiliência e aprendizagem contínua estão entre as competências comportamentais mais demandadas pelas empresas brasileiras até 2030 (World Economic Forum, 2025). Nessa perspectiva, os currículos acadêmicos devem passar por mudanças, com

a adoção de métodos de ensino-aprendizagem que incluam o desenvolvimento dessas habilidades (McLay; Thomasse; Reyes, 2023). Abordagens ativas de aprendizagem têm tido sucesso, pois protagonizam os alunos, potencializando a construção do seu conhecimento e a aquisição de novas descobertas, além de capacitá-los à crítica e à reflexão, impulsionando-os à resolução colaborativa de desafios ou problemas (Rodrigues *et al*., 2024).

Metodologias ativas tornam a aprendizagem alinhada aos interesses dos estudantes e estimulam sua participação efetiva no processo de ensino-aprendizagem (McLay; Thomasse; Reyes, 2023). Ao considerar as motivações dos alunos, os docentes incentivam o engajamento em projetos e tarefas nos quais eles possam contribuir com ideias próprias, fazendo com que atribuam significado ao que estão aprendendo (Broseghini *et al*., 2024). Essa construção conjunta favorece o envolvimento, estimula a autonomia e transforma o processo educativo em uma experiência mais relevante e formadora para os alunos (Capone, 2022).

Entretanto, apesar dos benefícios, a literatura também aponta limitações e críticas à adoção das metodologias ativas. Parte dos estudos que investigam seus efeitos, baseia-se predominantemente em dados de autoavaliação dos estudantes, o que nem sempre permite aferir ganhos reais de aprendizagem (Hartikainen *et al.,* 2019). Além disso, tanto a aprendizagem superficial quanto a aprendizagem profunda são influenciadas por múltiplos fatores, e contextos pedagógicos que não oferecem suporte adequado podem levar os estudantes à adoção de estratégias de aprendizagem superficiais, mesmo em metodologias ativas (Dolmans *et al.,* 2016). Nessa perspectiva, a presença de tutores bem-preparados é importante para o sucesso dessas metodologias, pois orientam os estudantes na análise dos problemas, ajudam a identificar lacunas de conhecimento e estimulam a reflexão crítica. Sem essa mediação qualificada, os alunos podem restringir-se a respostas superficiais ou à reprodução de conteúdo, sem desenvolver plenamente as habilidades previstas pela abordagem (Nguyen *et al.,* 2021).

Métodos ativos como a "Aprendizagem Baseada em Problemas", ou *Problem Based Learning* (PBL) em inglês, configuram-se como abordagens que exigem que os tutores possuam conhecimentos sólidos sobre seus propósitos e fundamentos pedagógicos, uma vez que sua atuação é determinante para orientar o processo de ensino-aprendizagem e evitar a adoção de estratégias superficiais por parte dos estudantes (Wijnia *et al*., 2024). A PBL é um método adotado no ensino superior desde a segunda metade do século XX, com o objetivo de aprimorar o desempenho acadêmico e fortalecer o desenvolvimento de *soft skills* (Lavado-Anguera; Velasco-Quintana; Terrón-López, 2024). Em seu formato original, o processo de ensino-aprendizagem começa com a apresentação de um problema ou situação desafiadora. A partir desse cenário, os alunos são estimulados a formular hipóteses e a identificar quais

conhecimentos precisam adquirir para solucionar os problemas, o que promove um aprendizado alinhado aos objetivos educacionais e exige maior protagonismo e envolvimento dos estudantes no próprio processo de aprendizagem (Trullàs *et al*., 2022).

Um maior protagonismo dos estudantes no processo de ensino-aprendizagem exige a consideração de suas características individuais. Nesse sentido, fatores como a autoestima e a satisfação com a abordagem de ensino tornam-se relevantes, sobretudo, na implementação de estratégias pedagógicas com as quais os alunos ainda não estão familiarizados. A autoestima, entendida como a percepção positiva ou negativa que o estudante tem de seu próprio valor, influencia diretamente sua motivação e seu desempenho acadêmico, afetando a capacidade de engajamento e de realização de tarefas educacionais (Yu *et al*., 2022). De forma complementar, a satisfação acadêmica constitui um indicador central para a permanência e a conclusão dos cursos, por refletir o bem-estar e o sucesso do estudante no ambiente universitário (Osti; Almeida, 2022). Nesse contexto, analisar indicadores de satisfação acadêmica pode orientar políticas e serviços institucionais que promovam o bem-estar estudantil (Öztekin *et al*., 2025).

Apesar do aumento da adoção da PBL no ensino superior a partir de 2000 (Veliverronena *et al*., 2025), essa metodologia ainda é pouco aplicada e estudada em cursos da área de Ciências Agrárias. Neste contexto, o objetivo deste estudo foi verificar a satisfação dos estudantes das disciplinas de Apicultura e Entomologia Florestal oferecidas na Universidade Federal de Minas Gerais, em relação à aplicação da PBL. A pesquisa buscou compreender se a aplicação da PBL impacta positivamente a percepção dos alunos quanto ao processo de aprendizagem, à relevância dos problemas abordados, à dinâmica dos grupos tutoriais e ao desenvolvimento de habilidades como trabalho em equipe e resolução de problemas. Adicionalmente, buscou-se identificar se a autoestima e fatores sociodemográfico exercem influência sobre a satisfação dos estudantes com a PBL.

1.2 OBJETIVOS

1.2.1 Objetivo geral

O objetivo foi analisar a percepção de estudantes em relação à utilização da metodologia PBL nas disciplinas de Apicultura e Entomologia Florestal oferecidas na Universidade Federal de Minas Gerais, Campus Montes Claros.

1.2.2 Objetivos específicos

- Identificar o perfil dos estudantes matriculados nas disciplinas;
- Descrever o uso da metodologia PBL em cada disciplina e eventuais oportunidades de melhoria nessa utilização;
- Discutir a satisfação dos estudantes em relação às disciplinas, bem como as habilidades por eles desenvolvidas;
- Identificar se a satisfação dos alunos com a PBL é influenciada por fatores sociodemográficos.

Este capítulo introdutório contextualiza o tema da pesquisa, apresenta a problemática que a motivou e explicita seus objetivos. Em seguida, o Capítulo 2 discute os fundamentos teóricos que sustentam o estudo, por meio de um levantamento exploratório da literatura, com o propósito de situar a pesquisa no campo e evidenciar lacunas ainda existentes. A partir do Capítulo 3, a dissertação adota o formato de artigos científicos, opção alinhada às diretrizes do programa de pós-graduação. Assim, o Capítulo 3 apresenta o artigo intitulado *"Satisfaction with Problem-Based Learning in a Forest Entomology Course"*, atualmente em fase de submissão a periódico científico. Por sua vez, o Capítulo 4 reúne o segundo artigo, intitulado *"Rethinking Beekeeping Education: Student Satisfaction with Problem-Based Learning in an Undergraduate Course"*, igualmente em processo de submissão. Por fim, o Capítulo 5 apresenta as considerações finais da dissertação, nas quais são retomados os principais resultados do estudo, suas contribuições, limitações e perspectivas para pesquisas futuras.

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CAPÍTULO 2 – REVISÃO DE LITERATURA

2.1 FUNDAMENTAÇÃO TEÓRICA DAS METODOLOGIAS ATIVAS

O construtivismo é uma teoria do conhecimento e da aprendizagem que afirma que o indivíduo constrói ativamente seu próprio saber (Taber, 2024). A teoria parte do pressuposto de que cada estudante possui um repertório próprio de conceitos e habilidades adquiridos ao longo da vida, e é a partir dessas experiências que ele interpreta situações, resolve problemas e constrói novos conhecimentos, tanto individual quanto coletivamente (Baviskar; Hartle; Whitney, 2009). Essa teoria fundamenta as metodologias ativas e está enraizada nas obras de Piaget, Vygotsky e Dewey (Taber, 2024; Majdi *et al*., 2025).

A aprendizagem, na perspectiva construtivista, é entendida como uma atividade dinâmica e contínua, em que o sujeito constrói o conhecimento a partir da interação com o meio (Vygotsky, 1980). Esse processo envolve os mecanismos de assimilação, acomodação e equilibração, pelos quais o estudante reorganiza suas estruturas cognitivas ao incorporar novas experiências (Piaget, 1954). Essa visão é complementada pela dimensão social da aprendizagem, em que o conhecimento é co-construído por meio da interação e da mediação com os outros, especialmente em contextos colaborativos (Vygotsky, 1980). O estudante pode aprender melhor quando é colocado em situações reais e desafiadoras, nas quais pode aplicar ativamente o conhecimento teórico para resolver problemas (Dewey, 1986).

Por muito tempo, tem-se questionado se o sistema educacional acompanha as transformações da sociedade. As instituições de ensino não podem continuar preparando estudantes para um mundo que, quando eles se formarem, já terá deixado de existir (Dewey, 1986). Os avanços tecnológicos e científicos, a evolução dos mercados e as novas formas de interação social impõem novos desafios aos ambientes educacionais (Lasakoswitsck, 2023). Nessa perspectiva, as universidades precisam deixar de atuar como instituições isoladas da realidade social e devem assumir plenamente suas funções formativas. Mais do que preparar profissionais para o mercado, a academia deve formar indivíduos capazes de compreender e se adaptar às dinâmicas do mundo do trabalho que estão em constante transformação (Jelodari; Zenouzagh; Hashamdar, 2025).

A essência do construtivismo se baseia na ideia de que o conhecimento não é algo a ser encontrado ou transferido, mas algo que se constrói (Baviskar; Hartle; Whitney, 2009). Nesse contexto, o educador não se limita à transmissão de conteúdos prontos, mas atua como mediador do processo de aprendizagem, propondo desafios e favorecendo a construção autônoma do conhecimento pelo estudante (Bell, 2020). O professor deve assumir a função de catalisador e

mentor, criando situações que favorecem o pensamento crítico, a experimentação e a descoberta, enquanto oferece suporte em um ambiente desafiador e estimulante (Bell, 2020). As instituições devem investir na formação continuada dos docentes, capacitando-os para adotar práticas que valorizem o protagonismo estudantil.

As metodologias de ensino orientam os processos de aprendizagem nesse cenário de rápidas mudanças nas demandas do mercado profissional. Entre elas, as metodologias ativas destacam-se por situar o estudante no centro do processo, estimulando sua participação e promovendo uma aprendizagem autônoma e alinhada à realidade (Costa; Reis, 2025). Entre as abordagens pedagógicas ativas que fortalecem o protagonismo do aluno, destaca-se a Aprendizagem Baseada em Problemas (Costa; Reis, 2025).

2.2 APRENDIZAGEM BASEADA EM PROBLEMAS / *PROBLEM BASED LEARNING* (PBL)

A Aprendizagem Baseada em Problemas surgiu no final da década de 1960 em cursos de medicina, como alternativa às limitações do ensino tradicional, caracterizado pela centralidade na transmissão de conteúdos, pelo predomínio de aulas expositivas e pela falta de articulação entre teoria e prática profissional (Sukackė *et al*., 2022; Kulo & Cestone, 2023). O método PBL foi inicialmente implementado pela McMaster University Medical School, no Canadá (Barrows, 1996). Nas duas décadas seguintes, passou a ser adotado por outras instituições de ensino superior na Europa e América do Norte, consolidando-se como uma abordagem instrucional eficaz (Barrows, 1996). As principais diferenças entre a abordagem tradicional com aulas expositivas e a Aprendizagem Baseada em Problemas são o papel do docente, o envolvimento do discente e o espaço de aprendizado (Kumar; Hsiao, 2007) (Tabela 1).

Tabela 1 – Comparação entre abordagem tradicional e abordagem baseada em problemas

(Continua)

	Abordagem tradicional	**Aprendizagem baseada em problemas**
Docente	Guia o pensamento do estudante e avalia os alunos.	Mentora os alunos e, quando necessário, direciona o aprendizado, fomentando engajamento no processo de pensamento crítico e avalia os estudantes.

(Conclusão)

D**iscente**	Escuta e resolve o problema a partir de parâmetros direcionados, é um aprendiz passivo.	Trabalha em grupo, participa de discussões, pensa criticamente para resolver os problemas.
Espaço de aprendizado	Espaço fechado.	As discussões ocorrem em um espaço fechado, mas o real aprendizado ocorre fora da sala de aula.

Fonte: Kumar e Hsiao (2007).

A PBL pode ser definida como um processo de aprendizagem que surge do esforço dos alunos para compreender ou resolver um problema (Smith *et al*., 2022). A PBL é uma abordagem centrada no aluno, que o prepara para realizar pesquisas, integrar teoria e prática e aplicar conhecimentos e habilidades para desenvolver uma solução viável para um problema definido (Tang *et al*., 2020). Seu objetivo principal é fazer com que os alunos construam uma base de conhecimentos relacionados aos problemas e desenvolvam habilidades para solucioná-los (Kulo; Cestone, 2023). Apesar de haver diversas formas de aplicação, especialmente na área da saúde, existe um modelo-base composto por cinco características fundamentais que estão presentes em todas as abordagens PBL (Barrows, 1996; Smith *et al*., 2022):

- O estudante deve ser o protagonista da própria aprendizagem. Sob a orientação de um tutor, cabe a ele reconhecer o que precisa aprender, definir estratégias e compreender o problema proposto de forma crítica e autônoma;
- O aprendizado deve ocorrer em pequenos grupos. Ao final de cada unidade curricular, os grupos são reorganizados, possibilitando a convivência e a cooperação com diferentes colegas;
- O tutor deve atuar como um facilitador ou guia para o grupo, estimulando a reflexão por meio de perguntas que incentivem os alunos a pensarem criticamente e a conduzir seu próprio processo de aprendizagem. Ele não deve transmitir conteúdos prontos;
- Os problemas devem ser autênticos e estimular o aprendizado, fornecendo contexto e motivação. Eles devem simular situações reais enfrentadas na prática profissional, levando os estudantes a perceberem quais conhecimentos precisam adquirir para compreendê-los. O problema deve favorecer a integração de diferentes áreas e favorecer o desenvolvimento de habilidades;

- A aprendizagem deve ser autodirigida. Os alunos devem buscar ativamente novos conhecimentos por meio do estudo individual, guiados pelas dúvidas e lacunas identificadas durante as discussões em grupo. Posteriormente, eles devem compartilhar suas descobertas, comparar ideias e debater os conteúdos, promovendo uma construção coletiva e sólida do conhecimento.

A aplicação da metodologia pode ser feita em sete passos, que guiam os estudantes através da resolução de um problema e do autoestudo (Barrows, 1996). O processo começa com a leitura do problema e a compreensão de termos e conceitos, garantindo que todos no grupo compreendam o texto da tarefa e partam de um ponto comum. Em seguida, o grupo formula e entende o problema, que direciona toda a sessão. Os passos seguintes incluem o *brainstorming* de ideias e palavras-chave e a discussão dos conhecimentos prévios. Posteriormente, os alunos devem definir os objetivos de aprendizagem específicos, estabelecendo o foco para o estudo individual. Após essa fase, os estudantes passam ao autoestudo, etapa central da PBL, na qual assumem a responsabilidade pelo próprio aprendizado para atender aos objetivos definidos. O processo se conclui na sessão seguinte, com a discussão e avaliação por pares, quando os alunos compartilham, discutem e debatem suas respostas, chegando a conclusões comuns para os problemas definidos (Barrows, 1996; Wang *et al*., 2016).

Existem quatro principais formas de implementação da metodologia, classificadas conforme o tipo de parceria estabelecida pelos docentes (Chen; Kolmos; Du, 2021), incluindo a aplicação da PBL de maneira independente, dentro da própria disciplina do professor; adoção conjunta com outros docentes da instituição; desenvolvimento de projetos em colaboração com empresas; e integração do método em todo o percurso formativo dos estudantes, abrangendo o currículo como um todo (Chen; Kolmos; Du, 2021). Independentemente da forma de aplicação, no geral, a PBL envolve a formação de grupos que buscam resolver problemas baseados em situações reais por meio da autoaprendizagem, e as sessões são voltadas ao desenvolvimento de competências práticas e *soft skills*.

As estratégias de implementação da PBL podem variar em função das particularidades culturais e dos diferentes sistemas educacionais, que ocorrem tanto ao nível curricular quanto dos cursos (Moslemi Nezhad Arani; Zarei; Sarani, 2023). Assim, a PBL pode ser adaptada a diferentes formatos, desde abordagens centradas em problemas até combinações com a Aprendizagem Baseada em Projetos (PjBL), podendo ser aplicada tanto em disciplinas isoladas quanto em contextos multidisciplinares (Sukackė *et al*., 2022). Ainda que essas adaptações sejam diversas, o princípio central da PBL permanece sendo promover a autonomia dos

estudantes, incentivando-os a se tornarem protagonistas do próprio processo de aprendizagem (Chen; Kolmos; Du, 2021).

A aplicação da PBL foi investigada em alguns cursos de universidades brasileiras. Em uma faculdade do Ceará, o método tradicional foi combinado com a PBL e mostrou que esse modelo híbrido favoreceu níveis mais elevados de autoeficácia entre estudantes de Medicina, quando comparado ao ensino baseado exclusivamente em aulas expositivas (Kubrusly *et al*., 2024). De forma semelhante, a PBL foi aplicada em conjunto com a alfabetização midiática e informacional em um curso de Química em uma instituição do Espírito Santo, resultando no aprimoramento das competências dos estudantes, na melhoria do desempenho na resolução de problemas, no aumento do engajamento na comunicação e no trabalho em equipe, bem como no desenvolvimento da consciência socioambiental (Pereira *et al*., 2022). Em cursos de Engenharia de *Software* em três universidades do Acre, a PBL foi associada à Teoria da Aprendizagem Experiencial (ELT), resultando em maiores níveis de motivação e engajamento (Almeida; França, 2022). Na formação de professores de Música do Instituto Federal de Educação, Ciência e Tecnologia do Sertão Pernambucano, a metodologia PBL melhorou a relação entre docente e discente, estimulou a autonomia, fortaleceu a identidade profissional e desenvolveu competências de trabalho colaborativo (Da Fonsêca Barros; Penna, 2023).

Apesar do aumento do uso da PBL, estudos envolvendo sua aplicação ainda são escassos nas Ciências Agrárias (Lucena *et al*., 2025). Alunos de Medicina Veterinária da Itália relataram alto nível de satisfação com a utilização da PBL (Broseghini *et al*., 2024). Em uma universidade canadense, a PBL foi associada à Aprendizagem Baseada em Equipes (TBL) em uma disciplina de Manejo Sustentável do Solo, e os resultados ressaltaram a importância de elaborar casos com nível adequado de complexidade, de evitar múltiplos desfechos que comprometam a coerência dos problemas, de garantir alinhamento com os objetivos de aprendizagem e de manter grupos equilibrados como aspectos centrais para uma implementação eficaz da metodologia (Krzic; Brown; Bomke, 2020). Na Indonésia, a Aprendizagem Baseada em Projetos, ou, em inglês, Project Based Learning (PjBL), e a PBL contribuíram para o ensino de tecnologia agrícola (Rais *et al*., 2021). Apesar desses avanços, permanece uma lacuna significativa de pesquisas no campo das Ciências Agrárias, o que evidencia a necessidade de ampliar investigações sistemáticas sobre a aplicação da PBL nessa área, especialmente em diferentes contextos formativos, de modo a consolidar evidências que subsidiem sua adoção pedagógica e orientem práticas docentes mais efetivas.

2.3 METODOLOGIAS ATIVAS APLICADAS AOS CURSOS DE ENGENHARIA FLORESTAL

Metodologias ativas aplicadas em cursos de Engenharia Florestal contribuíram para o desenvolvimento de competências acadêmicas e profissionais. Na Inglaterra, em um curso de graduação em Silvicultura, a PBL promoveu pensamento crítico, autonomia, capacidade de resolver problemas, trabalho em equipe, prática reflexiva e a integração de conhecimentos entre diferentes áreas do currículo, competências necessárias para a futura profissão (Leslie; Wilson, 2009).

Nos Estados Unidos, o uso de dispositivos inteligentes, como smartphones e tablets, foi empregado como ferramenta pedagógica em aulas de Silvicultura, aumentando a interação, a criatividade, a aplicação prática dos conteúdos e o engajamento dos estudantes. Contudo, essa prática também trouxe desafios, como o risco de distração e a necessidade de planejamento cuidadoso para garantir seu uso pedagógico adequado (Windmuller-Campione; Carter, 2017).

Uma abordagem baseada em casos (*case-centered*) foi implementada em um módulo teórico-prático voltado ao ensino de Métodos de Exploração Geofísica em um curso de Engenharia Florestal na Espanha (Alte-da-Veiga *et al*., 2022). Os alunos desenvolveram competências operacionais em campo, manipulação de dados, literacia gráfica, integração entre teoria e prática, pensamento crítico, aprendizagem colaborativa e comunicação em grupo (Alte-da-Veiga *et al*., 2022).

Na Suíça, pesquisadores integraram jogos educativos ao ensino de Silvicultura, proporcionando experiências que estimularam pensamento crítico e transdisciplinar, resolução colaborativa de problemas, empatia, desenvolvimento de *soft skills* como liderança, gestão e comunicação, além de habilidades de tomada de decisão (Waeber *et al*., 2023).

No contexto brasileiro, foram avaliados os resultados de aprendizagem percebidos de um grupo de estudantes expostos à PBL do curso de Engenharia Florestal da Universidade Federal Rural de Pernambuco. Os estudantes indicaram ter desenvolvido habilidades técnicas, empreendedoras e interpessoais relacionadas à silvicultura, enfatizando a natureza interdisciplinar da PBL (Lucena *et al*., 2025).

Apesar de alguns exemplos, a PBL pode ser mais bem explorada na Engenharia Florestal. As experiências descritas na literatura são pontuais e concentram-se principalmente em disciplinas de silvicultura, enquanto outras áreas, como a proteção florestal, permanecem inexploradas.

2.4 METODOLOGIAS ATIVAS APLICADAS EM ENTOMOLOGIA

O ensino da entomologia tem incorporado abordagens pedagógicas alternativas tanto na educação básica quanto no ensino superior, com a maior parte das pesquisas concentrando-se na educação básica. Isso ocorre porque crianças e adolescentes costumam apresentar forte aversão a insetos, o que torna o trabalho dos professores mais desafiador (Miller *et al*., 2025). Atividades entomológicas desenvolvidas de forma participativa, como práticas de campo, manipulação de espécimes, jogos e investigações guiadas, podem contribuir para reduzir esse estigma e tornar o contato com insetos uma experiência mais estimulante (Miller *et al*., 2025).

O programa de extensão "A Importância das Formigas", baseado em metodologias ativas, foi desenvolvido para alunos do ensino fundamental da Flórida para avaliar como formigas podem ser utilizadas como organismos modelo no ensino de conceitos ecológicos. Os resultados indicaram aumento no conhecimento sobre espécies invasoras, maior interesse e menor estigmatização em relação aos insetos (Zollota *et al*., 2023). Estações de aprendizagem com artrópodes vivos permitiram que turmas do ensino fundamental da Virgínia manipulassem e observassem os animais de perto, aumentando a aceitação e o interesse dos alunos por insetos, mesmo entre aqueles que inicialmente relataram fobia (Miller *et al*., 2025).

A gamificação foi aplicada no Brasil para estudantes do ensino fundamental que participaram do jogo *Insects GO*, uma atividade gamificada inspirada no Pokémon GO. Os resultados mostraram uma melhora na retenção de termos entomológicos essenciais, indicando que o jogo foi eficaz para a formação de memória de longo prazo, além de aumentar o engajamento dos alunos nas aulas (Wommer; Sepel; Loreto, 2023). Um estudo da Universidade Federal de Viçosa mostrou que uma atividade baseada em jogos de cartas foi útil como ferramenta de ensino nas disciplinas de Entomologia e Zoologia dos Invertebrados, melhorando os resultados de aprendizagem dos alunos (Cosme; Turchen; Guedes, 2020).

Tecnologias 3D foram usadas com estudantes do ensino fundamental em Taiwan no ensino de Entomologia Elementar. O desempenho de aprendizagem foi melhor no grupo que utilizou protótipos 3D de insetos, em comparação ao grupo que usou apenas recursos fotográficos (Lu *et al*., 2022). No ensino superior, um curso de extensão sobre "Identificação de insetos de importância agrícola para milho e soja", desenvolvido para universidades do Meio-Oeste dos Estados Unidos, integrou modelos 3D de espécimes com o objetivo de aprimorar a identificação morfológica de pragas. A intervenção aumentou o conhecimento dos estudantes, gerou altos níveis de satisfação com a aprendizagem e elevou sua motivação para aprender (Callohuari *et al*., 2025).

A aprendizagem baseada em investigação e projetos foi usada na disciplina de Entomologia Forense em uma universidade espanhola, melhorando a capacidade dos alunos de explicar processos biológicos de forma coerente e entender conceitos complexos da disciplina, fortalecendo a preparação científica dos futuros profissionais (Fontana-Bria *et al*., 2025).

2.5 RELAÇÃO ENTRE A PBL E A SATISFAÇÃO ACADÊMICA

A satisfação acadêmica é uma atitude de curto prazo resultante das experiências dos estudantes com o serviço educacional, com impacto direto na motivação, recrutamento e permanência na universidade (Rahmatpour; Sharif Nia; Peyrovi, 2019). Diante do aumento do número de ingressantes no ensino superior, o interesse por compreender os fatores que favorecem a permanência e a conclusão dos cursos tem se intensificado, tornando a satisfação acadêmica uma dimensão estratégica para instituições que buscam atrair e reter estudantes (Azila-Gbettor *et al*., 2022; Osti; Almeida, 2022).

A satisfação acadêmica pode envolver a percepção dos estudantes sobre o ambiente universitário, a estrutura curricular, os métodos pedagógicos e as interações com colegas e professores, além de estar relacionada ao cumprimento de metas e aspirações acadêmicas (Öztekin *et al*., 2025). Além disso, fatores psicossociais, como autoestima, motivação e percepção de apoio institucional, também influenciam a forma como o aluno vivencia o processo educativo, refletindo em sua satisfação acadêmica (Radzi *et al*., 2024; Hidalgo-Fuentes *et al*., 2024). Nessa perspectiva, metodologias ativas favorecem percepções mais positivas sobre o ensino oferecido pelas instituições (Sattarova; Groot; Arsenijevic, 2021).

A PBL tende a elevar a satisfação dos alunos com o ensino ao incentivá-los a formularem seus próprios objetivos de estudo em um ciclo contínuo de ação–reflexão–ação, favorecendo o autoaprendizado, a autoavaliação e a participação ativa nos grupos (Oliveira; Behnken, 2024). Esses aspectos se conectam ao desenvolvimento de competências como colaboração, autonomia e pensamento crítico, que por sua vez reforçam a percepção de qualidade educacional e contribuem para experiências de aprendizagem mais significativas (Belfor *et al*., 2018).

Na área médica, a relação entre a satisfação discente e a utilização da PBL no processo de ensino-aprendizagem é amplamente estudada. Estudantes de Ciências da Saúde da Etiópia submetidos à PBL relataram estar academicamente mais satisfeitos em comparação aos que participaram exclusivamente de aulas expositivas. Com base nesses resultados, os autores recomendam que o Ministério da Ciência e do Ensino Superior da Etiópia amplie a adoção

formal da PBL nas universidades, visando à melhoria da qualidade do ensino (Tadesse; Tadesse; Dagnaw, 2022). De forma semelhante, na Arábia Saudita, estudantes que participaram de cursos baseados em PBL apresentaram maior satisfação geral do que aqueles submetidos ao ensino tradicional, cujos pontos de insatisfação foram principalmente na supervisão, no ensino e na organização dos cursos tradicionais (Albarrak *et al*., 2013).

Resultados positivos também foram relatados em outras áreas do conhecimento. Em uma disciplina de Estatística de uma faculdade espanhola, o módulo PBL revelou níveis elevados de envolvimento, motivação e satisfação dos estudantes em comparação com os métodos educacionais tradicionais (Muerza *et al*., 2024). Na disciplina de Introdução à Física de uma universidade chilena, os alunos valorizaram positivamente a PBL, especialmente em termos de experiência acadêmica e contribuição para melhorar o aprendizado (Muñoz Alvarez; Greca; Arriassecq, 2025). No campo das Ciências Agrárias, alunos de Medicina Veterinária na Itália também expressaram alto nível de satisfação com as sessões de PBL (Broseghini *et al*., 2024).

A PBL favorece a construção e integração do conhecimento de forma mais eficiente do que métodos tradicionais (Muñoz Alvarez; Greca; Arriassecq, 2025). No entanto, sua adoção pode exigir uma fase inicial de adaptação. Em uma pesquisa com estudantes de Geografia, as primeiras avaliações da PBL foram baixas devido à mudança no papel do aluno e ao aumento da carga de trabalho (Ssemugenyi, 2023). Com o avanço do módulo, porém, os alunos passaram a reconhecer os benefícios da metodologia e apresentaram um aumento significativo da satisfação acadêmica, sugerindo que tanto professores quanto alunos precisam estar preparados para enfrentar os desafios iniciais associados à implementação da PBL (Ssemugenyi, 2023).

De modo geral, a satisfação estudantil é um componente estratégico para o sucesso da PBL, pois está vinculada não apenas ao engajamento e ao desempenho acadêmico, mas também ao desenvolvimento de competências cognitivas, sociais e profissionais que a metodologia favorece (Sattarova; Groot; Arsenijevic, 2021). A satisfação funciona como um indicador de qualidade educacional e de retenção universitária, reforçando que ambientes de aprendizagem motivadores tendem a reduzir evasão e fortalecer o vínculo dos estudantes com o curso (Rahmatpour; Sharif Nia; Peyrovi, 2019). Nesse contexto, uma reforma curricular que substitua ou complemente métodos tradicionais só é possível quando estudantes e tutores valorizam a proposta pedagógica e se sentem satisfeitos com sua implementação (Sattarova; Groot; Arsenijevic, 2021). Assim, compreender os fatores que influenciam a satisfação discente é essencial para orientar melhorias contínuas e consolidar a PBL como uma abordagem no ensino superior.

2.6 AUTOESTIMA NO CONTEXTO EDUCACIONAL

A autoestima é a percepção que o indivíduo tem do próprio valor e de sua autoconfiança (Rosenberg, 1965). Ela pode refletir crenças que a pessoa possui sobre si mesma, como a sua aparência, valores, emoções e comportamentos, que podem ser positivas ou negativas (Mello; Monteiro; Pinto, 2018) evidenciando como o indivíduo se percebe como bom, competente e digno (Wang *et al*., 2020).

A faixa etária entre 10 e 24 anos é marcada por transições biológicas, psicológicas, sociais e cognitivas que influenciam diretamente a construção da autoestima (Moksnes *et al*., 2024). Nesse contexto, a autoestima é um indicador de como os indivíduos percebem e gerenciam essas mudanças (Orth; Maes; Schmitt, 2015). Embora haja variações individuais, há uma tendência geral de crescimento da autoestima da adolescência até a idade adulta intermediária, atingindo seu ponto máximo entre os 50 e 60 anos e diminuindo gradualmente na velhice (Orth; Robins, 2022). Ao longo dessa trajetória, fatores como *status* de emprego, renda familiar, satisfação com o trabalho, vida acadêmica, relacionamentos e saúde contribuem para trajetórias de autoestima positivas ou negativas (Moksnes *et al*., 2024).

Pessoas com alta autoestima tendem a se ver como carismáticas, atraentes e capazes de estabelecer relações interpessoais satisfatórias (Radzi; Zakaria; Ahmad, 2024). Estudantes com níveis elevados de autoestima podem apresentar melhor desempenho acadêmico e menores índices de evasão, quando comparados àqueles com baixa autoestima (Radzi *et al*., 2024; Hidalgo-Fuentes *et al*., 2024). Estudantes com baixa autoestima podem apresentar altos níveis de procrastinação, por se perceberem incapazes de gerenciar suas tarefas (Lizarte Simón *et al*., 2024) O medo de resultados negativos e o receio de avaliação fazem com que evitem situações desafiadoras, levando ao adiamento de responsabilidades, sendo um mecanismo de autopreservação frente à possibilidade de fracasso (Hidalgo-Fuentes *et al*., 2024) e que pode gerar resistência a métodos de ensino que exigem autonomia e interação, como a PBL.

Ingressar na universidade apresenta desafios para a saúde mental e o bem-estar dos estudantes. A adaptação às novas demandas acadêmicas, somada ao afastamento de suas redes de apoio, pode gerar tensões emocionais que tornam esse público especialmente vulnerável a problemas psicológicos (Da-Silva-Domingues; Palomino-Moral; Del-Pino-Casado, 2025). Nessa transição, a autoestima influencia o desempenho acadêmico e pode limitar o processo de aprendizagem (Yu *et al*., 2022). Uma autoestima positiva favorece a disposição dos estudantes para assumir riscos, enfrentar desafios e desenvolver um senso de competência.

Nesse sentido, compreender a autoestima no contexto universitário é importante, pois ela atua como um fator mediador entre as demandas acadêmicas e a forma como os estudantes se engajam, respondem a desafios e se adaptam a metodologias ativas, como a PBL, que exigem maior autonomia, interação social e autorregulação da aprendizagem.

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CAPÍTULO 3 – PRIMEIRO ARTIGO

SATISFACTION WITH PROBLEM-BASED LEARNING IN A FOREST ENTOMOLOGY COURSE

3.1 ABSTRACT

Problem-based learning (PBL) is a student-centered method that promotes professional skills development through real-world problem solving. Yet, its success in university curricula depends on student satisfaction and support. This study aimed to assess the satisfaction and challenges of using the PBL methodology among Forest Entomology students in a Forest Engineering bachelor's program at a Brazilian university. After two PBL sessions during the semester, students completed a questionnaire divided into three sections: demographic data and self-esteem, their experience and satisfaction with the method, and open-ended questions for feedback on the method. The results show that most students perceived PBL positively and endorsed the method. They noted that the PBL sessions supported professional and soft skills development, such as teamwork and problem-solving. Students recommended continuing the approach and extending adoption into other undergraduate courses. The method received high student approval for enhancing technical, cognitive, and soft skills, while promoting active engagement. Despite challenges like group dynamics and reliance on self-directed learning, students appreciated its relevance to real-world problems.

Keywords: active methodology, higher education, pest management, self-directed learning, STEM education

3.2 INTRODUCTION

Active methodologies can shift teaching from memorization and repetition to reflective learning, enabling students to grasp complex concepts (Olmedo-Torre *et al*., 2021). One such methodology is problem-based learning (PBL), used in STEM courses to promote practical knowledge application and develop specific skills (Santhosh *et al*., 2023; Lavi; Marti, 2023). PBL encourages knowledge construction by engaging students in solving real-world problems, promoting autonomy, and developing self-learning skills, allowing the practical application of theory in scenarios that simulate professional and market contexts (Martín *et al*., 2021; De Barros; Paiva; Hayashi, 2023; Oller; Peña; Olmedo-Torre, 2024).

Technical skills are important but alone cannot guarantee career entry or stability in a constantly evolving job market (Abelha *et al*., 2020). In the forestry sector, evidence shows that employers value soft skills such as communication, creativity, leadership, and teamwork when hiring (Abelha *et al*., 2020; Rieg *et al*., 2022; Hakamada; Ferraz; Sulbaran-Rangel, 2023). PBL can help students develop these skills through active participation in their learning and group decision-making (Melguizo-Garín *et al*., 2022).

The effectiveness of PBL has been evaluated in health sciences (Feng; Wu; Bi, 2024; Lozano Terrón; Lorenzo Álvarez; Sendra Portero, 2024) and engineering (Zainol; Almukadi, 2020; Ruiz-Meza *et al*., 2021; Das et al., 2024). However, it is not widely used in agricultural sciences, with some evidence highlighting student satisfaction in veterinary medicine (Broseghini *et al*., 2024) and insights into the learning experiences of forest engineering students (Global assessment of forest education, 2022; Lucena *et al*., 2025).

Forest Entomology is an applied entomology course offered in Forest Engineering bachelor's programs in Brazil. The course focuses on pest identification and monitoring, Integrated Pest Management strategies, and the biology and behavior of key silvicultural pest species. However, like many required courses in Brazilian Forest Engineering programs, it often lacks integration between technical knowledge and practical application in real-world contexts (Hakamada *et al*., 2023; Lucena *et al*., 2025).

The implementation of PBL and student engagement with the methodology may vary across universities, shaped by the social, cultural, and institutional factors of each country or region (Broseghini *et al*., 2024). Identifying the barriers and potential of this method is necessary for adapting it to students, adjusting to fit local realities, and promoting personalized, inclusive education (Lavado-Anguera;Velasco-Quintana; Terrón-López, 2024).

Satisfaction with a teaching method often influences its adoption, as it is important to student engagement (Pham *et al*., 2024). Factors such as the quality of instruction, curriculum organization, and interpersonal relationships within the academic environment may impact student satisfaction with a learning method (Herrera Torres *et al*., 2024). Self-esteem and other personal traits can also affect students' performance and their ability to overcome challenges throughout their education (Yu *et al*., 2022). By addressing factors like satisfaction and self-esteem, this study informs forest science educators, universities, and educational institutions to identify weaknesses in the learning process and create strategies to support student learning, well-being, and professional development (Osti; Almeida, 2022).

To assess how PBL affects learning in Forest Entomology, we surveyed Forest Engineering students at a Brazilian public university. The study assessed multiple dimensions

of the PBL experience, including student satisfaction, acceptance, willingness to continue using the approach, perceived challenges, and overall perception of learning experience.

3.3 MATERIALS AND METHODS

3.3.1 Sampling

The study involved students enrolled in the Forest Entomology course, offered annually to Forest Engineering students at the Federal University of Minas Gerais (UFMG) in Montes Claros, state of Minas Gerais, Brazil. In this course, the instructor combines lectures with active learning techniques. The sample size consisted of 68 students, representing 93.1% of those enrolled during the evaluated years.

A repeated cross-sectional study design was conducted, with data collected annually over four consecutive years. The course had 18, 16, 19, and 20 students enrolled in 2022, 2023, 2024, and 2025, respectively. Most respondents were women (67.6%) and were in their seventh semester of the program (79.4%) (Table 2). More than half of the participants (58.8%) were between 22 and 26 years old, and the majority attended public high schools.

Table 2 – Demographic information of the sample (n = 68).

(Continue)

Demographics	Classification	Number	Frequency (%)
Gender	Female	46	67.6
	Male	22	32.4
	Total	68	100.0
Academic semester	Third	1	2.1
	Fifth	1	2.1
	Sixth	1	2.1
	Seventh	54	79.4
	Eighth	1	1.5
	Ninth	8	11.7
	Tenth	2	2.9
	Total	68	100.0
Age	Between 17-21	23	33.8
	Between 22-26	40	58.8
	Between 27-31	3	4.4
	Over 31	2	3.0
	Total	68	100.0
High school attended	Public	59	86.8
	Private	9	13.2
	Public and private	0	0
	Total	68	100.0

(Conclusion)

Overall semester grade	Less than 60	5	7.3
	Between 60-69	11	16.2
	Between 70-79	18	26.5
	Between 80-89	21	30.9
	Between 90-100	3	4.4
	Did not respond	10	14.7
	Total	68	100
Self-esteem	High	36	53.0
	Medium	16	23.5
	Low	16	23.5
	Total	68	100.0

Source: own elaboration.

3.3.2 PBL sessions

In the initial weeks, the instructor focuses on lectures, incorporating techniques to encourage student interaction, with the first PBL session introduced in the eighth week. Each semester included two PBL sessions on integrated management of forest pests. The first session addressed a problem concerning the management of eucalyptus gall wasps in forest nurseries, and the second focused on a problem concerning termite control in wooden structures (Appendix A).

Each PBL session was divided into two parts: an opening session and a closing session. In the opening session, students were organized into groups of five to eight. They started by reading the problem individually, followed by a group reading. Students then discussed their prior knowledge of the problem, identified keywords and unfamiliar terms, defined the problems to be solved in the case, and set learning objectives needed to understand and solve the case. Students had one to two weeks to individually study the defined learning objectives.

In the closing session, each group shared what they studied and discussed each learning objective separately, comparing perspectives and ultimately proposing solutions to the identified problems. At the end of this session, each group presented its solutions to the class, and the instructor provided feedback on their proposals. To conclude the closing session, each group submitted a report summarizing the content developed during the sessions. Each PBL opening and closing session lasted approximately two hours. Throughout the study, the tutor responsible for applying the methodology remained the same during the four years of research. In addition, there were no changes in the structure of the PBL sessions, the problems used, or

the criteria for evaluating students, in order to ensure methodological consistency throughout the period analyzed.

The rubric for the PBL sessions included four criteria: problem-solving ability, skill in gathering and analyzing information, engagement in activities, and teamwork. Each criterion was scored on a scale from 0 to 5, with a maximum total of 20 points (Appendix A).

3.3.3 Questionnaire

The questionnaire, administered at the end of each semester, assessed student satisfaction and gathered their experiences with various aspects of the PBL methodology. It was designed and reviewed by the authors, graduate students, and instructors to balance structured quantitative data with qualitative narratives. Students were informed about the research and received an informed consent form before participating. Participation was voluntary, and the anonymous questionnaire included nine questions and twenty-one statements, divided into three sections (e.g., A, B, and C) (Appendix B). The research and questionnaire were approved by UFMG's Human Research Ethics Committee (approval number: CAAE 65362922.1.0000.5149).

In section A, students provided demographic information such as age, sex, the type of high school they attended (e.g., public, private, or mixed), and their current semester of enrollment. This section also included the Rosenberg self-esteem scale (Rosenberg, 1965), a tool used to assess self-esteem in university students (Cao; Liu, 2024). The self-esteem scale consists of ten statements (five positive and five negative) rated on a 4-point Likert scale. For positive statements, the response options were: 1 (“strongly disagree”), 2 (“disagree”), 3 (“agree”), and 4 (“strongly agree”). For negative statements, the scale is reversed: 1 (“strongly agree”), 2 (“agree”), 3 (“disagree”); and 4 (“strongly disagree”). The total score is calculated by summing the values of all responses, resulting in a range from 10 to 40. The self-esteem scale results were interpreted based on the total score: low (10 – 25), medium (26 – 29), and high (30 – 40) (García *et al*., 2019).

In section B, students' satisfaction with various aspects of the methodology was assessed, including the sessions, proposed problems, learning process, and tutorial group. Twenty-one statements were used to assess student satisfaction with the method, along with two additional questions about the challenges of PBL and the time spent on self-study. Students rated each statement on a five-point Likert scale, indicating their level of agreement with the

following options: 1 (“strongly disagree”), 2 (“partially disagree”), 3 (“neutral”), 4 (“agree”), and 5 (“strongly agree”).

Finally, section C included two open-ended questions regarding overall satisfaction and student feedback to offer critiques and suggest improvements to the method.

3.3.4 Data analysis

The data analysis was divided into three phases. First, descriptive statistics were calculated, then a comparative analysis was conducted to assess the influence of independent variables on the questionnaire items, and finally, inductive coding was used to analyze open-ended questions. To evaluate open-ended questions, Taguette software was used (Rampin; Rampin, 2021) and for the statistical analysis, we used SPSS software.

The internal consistency of the questionnaire was assessed using Cronbach’s alpha. We obtained $\alpha = 0.873$, indicating high internal consistency (Toro *et al*., 2022).

Frequencies were calculated to describe participants’ levels of satisfaction and self-esteem scores. Subsequently, a descriptive analysis of the sample was conducted, calculating the mean, median, and standard deviation for both satisfaction-related questions and self-esteem indicators to identify trends and patterns. The quantitative data from the questionnaires were analyzed in groups of statements addressing similar topics to enhance understanding (see Tables 3, 4, 5, and 6).

A comparative analysis was conducted to determine whether responses varied by independent variables (e.g., gender, high school attended, self-esteem, academic term, and age), which were grouped to address imbalance and ensure robustness in the analysis. Academic semesters were grouped into students in the seventh semester and those in other semesters. Ages were grouped as 21 or younger and those older than 21. Since data did not meet normality assumptions, the non-parametric Kruskal-Wallis test was applied. Analyses were performed to identify differences for each combination of explanatory variable and questionnaire statement.

For the open-ended questions, inductive coding was applied (Brooks *et al*., 2015) using thematic analysis to identify participants’ reported experiences. The coding process began with a thorough reading of the responses, followed by the generation of initial codes. These initial codes were refined into broader themes, which were then reviewed to ensure accuracy and comprehensiveness.

3.4 RESULTS

3.4.1 Satisfaction with PBL

Students expressed strong approval of the PBL methodology, as reflected in the average rating for the statement "*I enjoyed the PBL methodology.*" (4.57 ± 0.72) (Table 3). Most respondents also showed interest in continuing to learn through PBL within the course (4.65 ± 0.54) (Table 3). Most students found the practical approach well-suited to the Forest Engineering course, considering the sessions both realistic (4.62 ± 0.49) and relevant to their professional field (4.59 ± 0.63) (Table 3). Students from public high schools were more likely to agree that the PBL sessions were realistic and reflected real-world situations compared to those from private schools (4.67 ± 0.48 vs. 4.22 ± 0.44, p = 0.0105). While most participants preferred PBL over traditional teaching methods (4.31 ± 0.87), the idea of a complete shift to PBL was met with less enthusiasm (3.66 ± 1.18) (Table 3).

Table 3 – Statements on overall satisfaction with PBL (n = 68).

Statements	Median	Mean	Standard deviation	Min.	Max.
The PBL sessions should be maintained as part of the studied discipline.	5	4.65	0.54	3	5
The PBL sessions were realistic and reflected real practical situations.	5	4.62	0.49	4	5
The PBL methodology is relevant to my field of study.	5	4.59	0.63	2	5
I enjoyed the PBL methodology.	5	4.57	0.77	2	5
The PBL sessions were well-organized and effective.	5	4.44	0.72	2	5
I did not have difficulties learning with the PBL methodology.	5	4.39	0.80	2	5
I prefer the PBL methodology to the method currently used.	5	4.31	0.87	2	5
PBL should replace the conventional study method in this discipline.	4	3.66	1.18	2	5

Source: own elaboration.

3.4.2 Tutorial group dynamics and skill development

Respondents had varying perceptions of interaction and collaboration during the sessions. They agreed that the sessions improved their ability to work in groups (4.18 ± 0.81) and recognized the importance of collaboration in solving the problems (4.38 ± 0.67) (Table 4).

Table 4 – Statements on the dynamics of the tutorial group (n = 68).

Statements	Median	Mean	Standard deviation	Min.	Max.
The tutorial group was important for solving the problem.	4	4.38	0.67	2	5
The PBL sessions improved my ability to work in groups.	4	4.18	0.81	2	5
I felt encouraged to regularly evaluate how the tutorial group members cooperated.	4	3.60	0.99	1	5

Source: own elaboration.

3.4.3 Stimuli and learning processes

Participants felt encouraged by the PBL sessions to formulate learning objectives (4.47 ± 0.74), integrate concepts across the course content (4.41 ± 0.74), and better understand the lecture classes in the course (4.50 ± 0.53) (Table 5). Seventh-semester students felt less motivated to summarize what they had learned in their own words compared to students from other semesters (4.22 ± 0.93 vs. 4.71 ± 0.47, p = 0.0436).

Table 5 – Statements on learning stimuli (n = 68).

(Continue)

Statements	Median	Mean	Standard deviation	Min.	Max.
The PBL sessions improved my understanding of the lectures taught during this academic semester.	4	4.50	0.53	3	5
I felt encouraged to clearly formulate the learning objectives.	5	4.47	0.74	2	5
I felt encouraged to integrate concepts across the course content.	5	4.41	0.74	2	5
I felt encouraged to apply what I learned to tasks/other situations/problems.	4	4.38	0.65	2	5

(Conclusion)

I felt encouraged to give/receive feedback during opening and closing sessions.	5	4.32	0.74	2	5
I felt encouraged to summarize what I learned in my own words.	4	4.32	0.87	1	5

Source: own elaboration.

Most students (42.7%) reported studying one to two hours per week for the closing sessions of the PBL. Just over a quarter (26.5%) studied two to three hours weekly. A small percentage of the students reported studying three to four hours (13.2%), less than an hour (8.8%), four to five hours (4.4%), or more than five hours per week (4.4%).

3.4.4 Effectiveness of the problems

Participants agreed that the PBL sessions improved their ability to solve real-world problems (4.31 ± 0.80) and boosted their confidence in tackling those problems (4.15 ± 0.90) (Table 6). Students also agreed that the time allocated during the closing sessions was sufficient to solve the problems (4.47 ± 0.68) (Table 6). Male students showed greater agreement than female students in stating that the problems were related to their prior knowledge (4.41 ± 0.59 vs. 3.96 ± 0.51, p = 0.0287).

Table 6 – Statements on the effectiveness of the problems (n = 68).

Statements	Median	Mean	Standard deviation	Min.	Max.
The time provided to solve the proposed problem was adequate.	5	4.47	0.54	3	5
The problems proposed during the PBL sessions improved my ability to solve real problems.	4	4.31	0.87	1	5
Participating in the PBL sessions improved my confidence and ability to solve a real problem.	4	4.15	0.92	1	5
The problems presented had some relation to my prior knowledge.	4	4.10	0.81	2	5

Source: own elaboration.

3.4.5 Challenges

Teamwork emerged as the most frequently reported challenge, with 32.9% of students struggling to collaboratively plan a solution, 20.5% reporting difficulty in reaching a solution, and 13.6% experiencing communication issues within their groups. In contrast, few students reported identifying the problem (10.2%) or dedicating time to self-study (2.3%) to be a challenge. Over one-fifth (20.5%) of students reported no difficulties at all.

2.4.6 PBL perceptions by self-esteem

The sample had a mean self-esteem score of 30 points (high). Among women, 23.9% (n = 11) had low self-esteem, 28.3% (n = 13) had medium self-esteem, and 47.8% (n = 22) had high self-esteem. Among men, 22.8% (n = 5) had low self-esteem, 13.6% (n = 3) had medium self-esteem, and 63.6% (n = 14) had high self-esteem.

Students with high self-esteem were more likely to assess cooperation within their tutorial groups than those with medium/low self-esteem (3.83 ± 0.94 vs. 3.34 ± 1.00, p = 0.0348). Students with high self-esteem were more likely to report increased confidence and problem-solving ability compared to those with medium/low self-esteem (4.33 ± 0.89 vs. 3.94 ± 0.88; p = 0.0217).

3.4.7 Thematic analysis

Responses to the open-ended questions revealed positive perceptions of PBL, including its ability to stimulate knowledge construction, develop personal and interpersonal skills, and enhance professional competencies. Students also offered suggestions for improving the methodology, such as creating unique problems for each tutorial group, incorporating images and more details into the problems, and increasing the number of sessions throughout the semester (Table 7).

Table 7 – Summary of themes, codes, and quotes reported by students.

(Continue)

Core themes	Sub themes	Frequency	Sample quotations
Positive perceptions about PBL	Satisfaction with the methodology	40	*"I'm very satisfied, bringing practical examples really helps to remember the subject [...]"*

(Continue)

	Appreciation of the methodology	22	*"It is a great teaching methodology."*
	Suggestion for application in other subjects	7	*"[...] I think other subjects should adopt it [...]"*
	Defense of combining PBL and traditional teaching	3	*"[...]it should be maintained in the subject along with the conventional teaching method. [...]"*
	Replacement of exams with weekly PBL	3	*"[...]replacing exams with weekly PBL sessions would be interesting."*
	Value of teacher feedback	2	*"[...]we can practice what we study at home with more colleagues and also with the teacher's critical opinion."*
	Desire for more PBL activities	1	*"[...] I wish there were more activities throughout the semester."*
Encouragement of knowledge building	Encouragement to study	14	*"[...] it challenges and encourages you to learn and understand the subject covered."*
	Contribution to learning the content	7	*"[...]it contributed to my learning."*
	Deepening specific content	3	*"[...]I learned much more from the content worked on in the PBL sessions than from those I studied for conventional exams."*
Personal and interpersonal skills	Value of teamwork	7	*PBL was very important for working in groups, and it also served as a good study incentive."*
	Development of skills for professional life	4	*"[...]I believe that in professional life, problem-solving will be frequent, so it's good to be prepared."*
	Interpersonal and communication skills	3	*"[...]improves communication skills and interpersonal relationships."*

(Conclusion)

Development of professional skills	Practical application of content	14	*"PBL guided us in solving real problems and showed how to put into practice what was studied, helping us understand how we can use this knowledge in future situations."*
	Simulation of professional practice	8	*"[...]I felt as if I were working and responsible for solving a problem [...]"*
	Valuing PBL as market preparation	5	*"[...]it is a method that drives us to solve something that could happen in the job market."*
Suggestions for methodology improvement	Diversified problems	4	*"I imagine a different problem for each group would be very effective [...]"*
	Clearer, more detailed problems with images	4	*"[...]could include photos [...] in some cases the language was a bit confusing."*
	More PBL sessions throughout the subject	4	*"There could be more PBL practices during the subject."*

Source: own elaboration.

3.5 DISCUSSION

3.5.1 General discussion

Students in the Forest Entomology course at UFMG reported high satisfaction with the PBL method, demonstrating its effectiveness in promoting learning and cognitive growth. Similarly, most Veterinary Medicine students in Italy reported satisfaction with the method in their classes (Broseghini *et al*., 2024). In contrast, only 50.9% of Health Sciences students in Ethiopia were satisfied with PBL (Tadesse *et al*., 2022). These variations suggest that satisfaction with PBL depends on the context and field of study. While it worked well in Forest Entomology, more research is needed to evaluate its impact across different disciplines and settings (Osti; Almeida, 2022).

Most Forest Entomology students (98%) supported continuing PBL in their course. Similarly, over 83% of Architecture students in Azerbaijan favored its use in their modules

(Sattarova *et al*., 2021). These high approval rates show that students recognize PBL's ability to deepen understanding of content and develop important skills. As one student noted, "*...PBL added knowledge and stimulated learning. The sessions reflected problems we will face in the job market*".

While students showed high satisfaction with PBL and preferred it over traditional lectures, many believe it should not entirely replace conventional teaching. This resistance may arise from the insecurity PBL can create, as it requires autonomy and self-directed learning. Such feelings are often stronger among students new to PBL, particularly those accustomed to traditional lectures (Sukackė *et al*., 2022; Su, 2024), like the Forest Entomology students. A better approach may be combining PBL with lectures and other teaching methods. The combination of methods can develop cognitive, socio-emotional, and technical skills more effectively than using a single approach (Chang; Yan; Lu, 2022; Köpeczi-Bócz, 2024). For example, integrating PBL with flipped classrooms in a Viticulture course in Hungary improved learning outcomes and boosted student motivation compared to using the flipped classroom alone (Köpeczi-Bócz, 2024).

Students reported that PBL group activities improved their ability to argue, communicate, and interact with peers. Working together to solve problems encouraged them to negotiate ideas, consider different perspectives, and make collective decisions. As one student noted, "*... discussions with my peers make me more confident in presenting the proposed solution to the problem*". Such feedback shows how PBL strengthens social and collaborative skills (Sukackė *et al*., 2022; Lucena *et al*., 2025), stimulating the development of soft skills that improve career advancement opportunities for students in Forest Sciences (Hakamada; Ferraz; Sulbaran-Rangel, 2023; Lucena *et al*., 2025).

Forest Entomology students cited planning and communication within groups as the main challenges of PBL, likely due to the stress of constant negotiation and interaction (Broseghini *et al*., 2024). Similarly, engineering students in Lithuania faced difficulties with group work during PBL in Physics, citing interpersonal conflicts and the burden of non-contributing peers as major challenges (Marcinauskas *et al*., 2024). Tutor support is important in addressing these challenges, helping students manage conflicts while encouraging them to resolve issues independently during PBL.

Most Forest Entomology students spent one to two hours per week on self-study for PBL sessions. This aligns with Forest Engineering students in Brazil, where 36.5% dedicate one to three hours and 35.1% spend four to seven hours on self-study (INEP, 2018). For Forest Entomology students, this self-study time was dedicated entirely to PBL, showing its significant

role in their study routine and its impact on increasing engagement. However, the quality of engagement may matter more than the hours spent. In the Netherlands, Law students using PBL were more engaged and used their study time more effectively than those in traditional lectures (Wijnen *et al*., 2017). This may be because PBL encourages students to define their learning objectives, organize their studies, and seek knowledge purposefully. As one student noted: "... *PBL gave more focus to my studies than the traditional approach. It helped me think about the problem in an active way*".

Students reported greater motivation for learning, increased engagement when defining learning objectives, and a better ability to connect topics deeply. One student said, "*I learned much more from the content covered in the PBL sessions than from what I studied for the conventional exam*". Similarly, in a Project Management course in Norway, 69% of students reported achieving a deeper understanding of concepts, and 71% felt more connected to the content through PBL (Ngereja *et al*., 2020). In Forest Entomology, PBL promotes active engagement, improves teaching, and strengthens the understanding of key concepts, as seen in other disciplines (Fitrah *et al*., 2025).

PBL sessions boosted Forest Entomology students' confidence and problem-solving skills for real-world challenges. One student shared: "*It was very interesting because I felt as if I were working and responsible for solving a problem. It was motivating. It improved my speaking skills and interpersonal relationships*". PBL also has the potential to strengthen soft skills such as oral communication, teamwork, and proactivity among Forest Sciences students, as evidenced among Forest Engineering students in Brazil (Lucena *et al*., 2025). Both experienced professionals and recent graduates agree that these skills are often missing in Forest Engineering training in Brazil (Hakamada; Ferraz; Sulbaran-Rangel, 2023). PBL can help address this gap by equipping Forest Engineering students, as well as those in other Agricultural and Forest Sciences programs, with the tools needed for career success. Education in Agricultural and Forest Sciences should prioritize developing competencies through active methodologies like PBL, which prepare students not only with technical expertise but also for the human and social challenges of the workforce.

Some students suggested that each tutorial group address different problems, designed in greater detail and accompanied by images to clarify the context and reduce misinterpretations. Integrating visual and technological resources, such as images or videos of insects and their damage, could make problems more engaging and relevant, especially for visually oriented learners. Studies show that using videos and 3D images during PBL sessions increased interest and understanding among medical students in China and Japan (Ikegami *et*

al., 2017; Sun *et al*., 2022). Applying similar strategies could enhance the learning experience of PBL for Forest Entomology students.

3.5.2 Limitations and future directions

Although this study spanned four years of applying the methodology, the sample was limited to a small group of students from a single university. Satisfaction may have been influenced by factors specific to the university, suggesting that similar research at other institutions could yield different outcomes. While the small sample size limits generalization, increasing it would be challenging. Achieving this would require the participation of Forest Entomology instructors from multiple universities, each with their own teaching styles, applying similar PBL exercises. However, it is unlikely that instructors would agree to modify their teaching methods over four consecutive years solely for this purpose. An alternative approach would be to conduct a study across multiple universities with instructors already using PBL in applied entomology courses, such as agricultural, forest, and forensic entomology. Each instructor could address common core questions while also addressing discipline-specific questions.

The data were collected through student self-reports, which may have prompted more positive responses than their actual experiences. This pattern may reflect social desirability bias, with students providing responses they perceive as more favorable or as aligning with the evaluator's expectations (Lucena *et al*., 2025). To minimize this bias, we used anonymous questionnaires with a Likert scale.

Future research should expand to include other subjects within the Agricultural and Forest Sciences programs, using objective measures such as performance tests to evaluate skill development. Additionally, studies should examine long-term knowledge retention, comparing content learned through PBL with that acquired in traditional lecture-based classes.

3.6 CONCLUSION

The results obtained over four years show high student satisfaction with PBL and demonstrate its potential to develop both the technical and social skills necessary for forest engineers, particularly forest entomologists. Students expressed motivation and interest in continuing to learn through this method, acknowledging that the experience improved their teamwork abilities and other soft skills.

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CAPÍTULO 4 – SEGUNDO ARTIGO

RETHINKING BEEKEEPING EDUCATION: STUDENT SATISFACTION WITH PROBLEM-BASED LEARNING IN AN UNDERGRADUATE COURSE

4.1 ABSTRACT

Active-learning methods, such as problem-based learning (PBL), help students develop interpersonal skills for professional practice. We investigated Beekeeping students' satisfaction, acceptance, intention to continue using PBL, and the main challenges they experienced with this method at a Brazilian public university. Questionnaires were administered over four consecutive years (2022–2025) and included items on demographic information, self-esteem, Likert-scale statements, and open-ended questions. Beekeeping students were satisfied with PBL and reported improved problem-solving skills. Students most preferred PBL to traditional teaching methods, but did not want the traditional approach to be completely replaced. Gender, age range, and self-esteem influenced beekeeping students' satisfaction with PBL. Peer communication and joint planning of solutions posed the greatest challenges for these students. PBL can be an effective approach for Beekeeping students to develop interpersonal competencies and a good approach to teach beekeeping in undergraduate courses.

Keywords: active methodology, apiculture, higher education, honeybee, self-directed learning.

4.2 INTRODUCTION

Agricultural Science programs still rely mainly on lectures, and many students graduate without the interpersonal skills they need for professional practice (Reinhard *et al*., 2021; Hakamada *et al*., 2023; Broseghini et al., 2024). Students can develop these skills through classroom interactions and discussions with peers or instructors (Gordon *et al*., 2021), but informal exchanges alone do not fully promote them. Active methods, such as Problem-Based Learning (PBL), better promote the development of soft skills (Naseer *et al*., 2025). PBL is learning that grows out of understanding and solving a problem (Smith *et al*., 2022). This method was widely adopted in medical education in the late 1960s (Trullàs *et al*., 2022) and has more recently expanded to other STEM fields (Smith *et al*., 2022). It enhances creativity (Ji; Wong, 2025), critical thinking (Broseghini *et al*., 2024), problem-solving (Jelodari; Zenouzagh; Hashamdar, 2025), communication (Li *et al*., 2019), collaboration, and autonomy in learning (Muhtadi; Hukom, 2025).

In PBL, learning is student-centered and occurs through investigation, reflection, and practical application of knowledge (Jamshidi *et al*., 2021; Naseer *et al*., 2025). Students define

their learning objectives, engage in self-directed study, share and apply what they learn, integrating diverse content throughout the educational process (Sharma *et al*., 2023; Honra; Monterola, 2025). PBL is well accepted by students across disciplines and is associated with improved academic performance (Muñoz Alvarez *et al*., 2025). Although it has been explored and evaluated in Engineering (Vanoye-Garcia & Menchaca-Torre, 2024; Ortiz Moreno *et al*., 2025), Health Sciences (Avraam *et al*., 2025; Wang *et al*., 2025), Marketing (Rosário; Dias, 2024), Social Sciences (Lenkauskaitė *et al*., 2021), and Education (Li *et al*., 2025), its adoption in Agricultural Sciences has been limited (Erickson *et al*., 2020; Broseghini *et al*., 2024; Lucena *et al*., 2025).

The Beekeeping course is mandatory in Animal Science programs in Brazil and offered as an elective in other Agricultural Science programs. As in other courses in this field, a gap persists between theoretical knowledge and practical application due to the predominance of lecture-based instruction (Kumar; Kumar, 2014). To address this gap, Beekeeping education has incorporated new methods and technologies, such as gamification and augmented reality (Silva *et al*., 2020; Strousopoulos *et al*., 2023), to enhance learning. However, the use of PBL in this context remains underexplored, highlighting the need to investigate active methods that foster practical skills and enhance student engagement.

The success of active learning methods, such as PBL, depends on the social, cultural, and institutional context in which students and universities are situated (Li; Carroll, 2020). When introducing a new teaching approach, it is necessary to assess students' perceptions and satisfaction with the method and adapt it to the local context (Wong; Chapman, 2023). Psychological factors, such as self-esteem, can also influence students' motivation, performance, and satisfaction with new learning approaches (Zheng *et al*., 2020; Acosta-Gonzaga, 2023).

By investigating students' satisfaction with new methods, educators can identify gaps in the learning process and develop strategies that support both academic and personal development (Osti; Almeida, 2022). The relationship between PBL and student satisfaction has been studied in fields such as Architecture (Sattarova; Groot; Arsenijevic, 2021) and Veterinary Sciences (Broseghini *et al*., 2024). However, there is still no evidence about how Beekeeping students perceive this approach. This gap is particularly relevant in the post-pandemic context, which disrupted teaching-learning dynamics (Erickson; Wattiaux, 2021). Understanding students' satisfaction with PBL in this setting is therefore essential to assess its pedagogical value and justify its use as an appropriate way to address the specific challenges of this course.

To assess students' perceptions of PBL in a Beekeeping course, we conducted a survey among Animal Science students at a Brazilian public university. The study examined several dimensions of their experience with PBL, including satisfaction, acceptance, willingness to continue using it, perceived challenges, and overall views of the learning process. By examining these students' perceptions of PBL, this study offers insights that can help educators in Agricultural Sciences and higher education institutions identify weaknesses in the learning process and develop strategies to support students' learning, well-being, and professional development.

4.3 MATERIALS AND METHODS

4.3.1 Sampling

The study involved students enrolled in the Beekeeping course at the Federal University of Minas Gerais (UFMG), Montes Claros campus, Minas Gerais, Brazil. The course is offered once a year as a mandatory subject for Animal Science students and as an elective to students from other programs. It combines theoretical lectures with active learning techniques that promote interaction between students and the instructor, as well as practical classes in which students apply the concepts learned to consolidate the content. PBL sessions were implemented during these practical classes. The sample consisted of 137 students, representing 83.5% of all students enrolled in the course in the years evaluated.

A repeated cross-sectional study was conducted, with data collected by questionnaires over four consecutive years. The course had 38, 46, 35, and 45 enrolled students in 2022, 2023, 2024, and 2025, respectively. Most respondents were female and in their second semester of the program (Table 8). More than half were between 17 and 22 years old, and most had completed high school in a public school.

Table 8 – Demographic information of the sample (n = 137).

(Continue)

Demographics	Classification	Number	Frequency (%)
Gender	Female	92	67.2
	Male	45	32.8
	Total	137	100.0
Academic semester	Second	119	86.9
	Fourth	13	9.5
	Sixth	4	2.9

(Conclusion)

	Eighth	1	0.7
	Total	137	100.0
Age	Between 17-21	96	70.1
	Between 22-26	34	24.8
	Between 27-31	4	2.9
	Over 31	3	2.2
	Total	137	100.0
High school attended	Public	102	74.5
	Private	26	19.0
	Public and private	9	6.5
	Total	137	100.0

Source: own elaboration.

4.3.2 PBL sessions

Practical classes included PBL sessions starting in the third week. Two PBL sessions were held each semester. In the first, students work on a problem involving the selection of the apiary site and hive stocking. In the second, they designed a field experiment to demonstrate the effect of bee pollination on agricultural productivity (Appendix A).

Each PBL session had an opening and a closing phase, each lasting one hour and held during practical classes. In each class, students worked in groups of four to six. During the opening phase, they received the problem, first read it individually, and then read it together. They discussed their prior knowledge, identified key concepts and unfamiliar terms, and, based on this discussion, defined the problems and set the learning objectives needed to solve them. The interval between the opening and closing phases, reserved for individual study, ranged from one to two weeks.

In the closing phase, the groups shared the results of their studies and discussed each learning objective, comparing interpretations and collaboratively developing solutions to the problems. At the end of the discussions, they presented their proposals and received feedback from the tutor. Finally, each team submitted a report summarizing the discussions from both phases.

The rubric for the PBL sessions assessed problem-solving ability, skill in collecting and analyzing information, engagement in activities, and teamwork (Appendix A).

4.3.3 Questionnaire

The questionnaire, administered at the end of the semester, was developed based on the validated questionnaire proposed by Sattarova *et al*. (2021) and revised by the authors, with the collaboration of graduate students and faculty members, aiming to balance quantitative data with qualitative narratives. The study and the questionnaire were approved by the Human Research Ethics Committee of UFMG (approval number: CAAE 65362922.1.0000.5149).

The questionnaire included nine questions and twenty-one statements divided into three sections (i.e., A, B, and C) (Appendix B). Section A gathered demographic information, including age, sex, the type of school attended during high school (public, private, or mixed), and the semester in which students were enrolled. This section also included the Rosenberg Self-Esteem Scale (Rosenberg, 1965), which has been used to assess university students' self-esteem in similar studies (Cao; Liu, 2024). The self-esteem scale consists of ten statements (five positive and five negative) rated on a four-point Likert scale. For positive statements, responses ranged from 1 (strongly disagree) to 4 (strongly agree), while scores for negative statements were reversed. The total score ranges from 10 to 40 points, with self-esteem classified as low (10–25), moderate (26–29), or high (30–40) (García *et al*., 2019).

Section B investigated students' level of satisfaction with different aspects of the PBL methodology, such as the sessions, the problems presented, the learning process, and group work. Twenty-one statements related to these elements were included, along with two questions addressing the difficulties encountered and the time devoted to self-directed study. Each item was rated on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Section C included an open-ended question on overall satisfaction with the method and another question for suggestions and criticisms for improving the approach.

4.3.4 Data analysis

Data analysis was conducted in three phases. First, descriptive statistics were calculated; second, a comparative analysis was performed to examine the influence of independent variables on dependent variables; and finally, inductive coding was used to analyze the open-ended questions. Descriptive and comparative analyses were performed using RStudio software (R Core Team, 2024). The analysis of open-ended questions was carried out using Taguette software (Rampin; Rampin, 2021).

The internal consistency of the questionnaire was assessed using Cronbach's alpha and McDonald's omega. Because the data were ordinal, the omega coefficient was calculated from

a polychoric correlation matrix, as recommended for Likert-type scales (Revelle; Zinbarg, 2009). Cronbach's alpha was 0.93, indicating excellent internal consistency (Toro *et al*., 2022). The total omega was 0.95, also indicating excellent internal consistency and confirming the high reliability of the instrument (González-Mendiondo; Moyano, 2023).

Quantitative data were analyzed using descriptive statistics to summarize and interpret participants' responses. For satisfaction-related items, we calculated mean, median, standard deviation, minimum, and maximum values to identify trends and patterns. Questionnaire items were analyzed in groups of statements addressing the same theme to facilitate interpretation (see Tables 9, 10, 11, and 12).

We conducted a comparative analysis to examine how the independent variables (sex, type of high school attended, level of self-esteem, age, and academic semester) affected the dependent variables. To balance the sample and strengthen analysis, some categories were grouped: academic semester into second semester vs. other semesters; type of high school attended into public school vs. others; and age into up to 21 years vs. over 21 years. Because data did not meet normality assumptions, we used the non-parametric Kruskal–Wallis test. Analyses were performed separately for each combination of explanatory variable and questionnaire item to detect differences.

Open-ended responses were analyzed using inductive coding (Brooks *et al*., 2015). The process began with a detailed reading of the answers and the generation of initial code. These codes were then refined into broader themes, which were reviewed to ensure the accuracy and coherence of the analysis.

Throughout the study, the tutor responsible for applying the methodology remained the same during the four years of research. In addition, there were no changes in the structure of the PBL sessions, the problems used, or the criteria for evaluating students, in order to ensure methodological consistency throughout the period analyzed.

4.4 RESULTS

4.4.1 Satisfaction with PBL

Most students appreciated the PBL methodology (4.24 ± 0.85) and expressed interest in continuing to learn with this approach (4.44 ± 0.71), as reflected in the statement "*The PBL sessions should be maintained as part of the studied discipline*" (Table 9). They considered the sessions realistic and representative of real-life situations (4.39 ± 0.68) (Table 9). Students over 21 years of age agreed more strongly that PBL is relevant for professional training than those

younger than 21 or younger (4.32 ± 0.99 vs. 4.10 ± 0.62; p = 0.0433). Most participants preferred PBL to traditional teaching methods (4.03 ± 0.90) and reported learning without difficulty using this approach (4.12 ± 1.04). However, they were unsure about fully replacing lecture-based classes with PBL, showing only a slight tendency toward agreement (3.31 ± 1.19) (Table 9).

Table 9 – Statements on overall satisfaction with PBL (n = 137).

Statements	Median	Mean	Standard deviation	Min.	Max.
The PBL sessions should be maintained as part of the studied discipline.	5	4.44	0.71	1	5
The PBL sessions were realistic and reflected real practical situations.	4	4.39	0.68	2	5
I enjoyed the PBL methodology.	4	4.24	0.85	1	5
The PBL methodology is relevant to my field of study.	4	4.17	0.89	1	5
I did not have difficulties learning with the PBL methodology.	4	4.12	1.04	1	5
I prefer the PBL methodology to the method currently used.	4	4.03	0.90	1	5
The PBL sessions were well-organized and effective.	4	4.00	0.92	2	5
PBL should replace the conventional study method in this discipline.	3	3.31	1.19	1	5

Source: own elaboration.

4.4.2 Tutorial groups and skills development

Students moderately agreed that the tutorial group was important for solving the problems proposed during the sessions (3.93 ± 0.83) (Table 10). They reported feeling only slightly encouraged to reflect on how group members cooperated during the sessions (3.85 ± 0.90) and considered the sessions moderately effective at improving their ability collaborate (3.74 ± 1.19) (Table 10).

Table 10 – Statements on the dynamics of the tutorial group (n = 137).

(Continue)

Statements	Median	Mean	Standard deviation	Min.	Max.

(Conclusion)

The tutorial group was important for solving the problem.	4	3.93	0.83	1	5
I felt encouraged to regularly evaluate how the tutorial group members cooperated.	4	3.85	0.90	1	5
The PBL sessions improved my ability to work in groups.	4	3.74	1.19	1	5

Source: own elaboration.

4.4.3 Learning processes and engagement

Students felt that the PBL sessions encouraged them to define learning objectives (4.28 ± 0.65), summarize what they had learned in their own words (4.15 ± 0.67), and make connections between the different topics addressed in the problems (4.10 ± 0.73) (Table 11).

Table 11 – Statements on learning stimuli (n = 137).

Statements	Median	Mean	Standard deviation	Min.	Max.
I felt encouraged to clearly formulate the learning objectives.	4	4.28	0.65	1	5
The PBL sessions improved my understanding of the lectures taught during this academic semester.	4	4.26	0.73	2	5
I felt encouraged to give/receive feedback during opening and closing sessions.	4	4.16	0.79	2	5
I felt encouraged to summarize what I learned in my own words.	4	4.15	0.67	2	5
I felt encouraged to integrate concepts across the course content.	4	4.10	0.73	1	5
I felt encouraged to apply what I learned to tasks/other situations/problems.	4	4.03	0.79	2	5

Source: own elaboration.

Most students (53.3%) reported studying one to two hours per week for the PBL closing sessions. Just over a quarter (24.8%) studied two to three hours per week. A small share studied

less than one hour (13.1%). Another 4.4% studied three to four hours, 2.2% studied four to five hours, and 2.2% studied more than five hours per week.

4.4.4 Perceived problem quality

Participants agreed that the PBL sessions improved their ability to solve real-world problems (4.23 ± 0.70) (Table 12). They also agreed that the time allocated for the closing sessions was sufficient to solve the problems (4.02 ± 0.89), however, they felt that the problems were only moderately connected to their prior knowledge (3.60 ± 1.02) (Table 12).

Table 12 – Statements on the effectiveness of the problems (n = 137).

Statements	Median	Mean	Standard deviation	Min.	Max.
The problems proposed during the PBL sessions improved my ability to solve real problems.	4	4.23	0.70	2	5
The time provided to solve the proposed problem was adequate.	4	4.02	0.89	1	5
Participating in the PBL sessions improved my confidence and ability to solve a real problem.	4	3.87	0.99	1	5
The problems presented had some relation to my prior knowledge.	4	3.60	1.02	1	5

Source: own elaboration.

4.4.5 Challenges

A total of 29.5% of students reported difficulty communicating with group members, and 23.8% reported difficulty planning a solution collectively. Identifying the problem (11.9%) and finding a solution (14.3%) were also cited as challenges. Only 6.2% of students considered the time allotted to find a solution insufficient. Slightly more than one-tenth (14.3%) reported no difficulties with PBL.

4.4.6 PBL perceptions by self-esteem

The sample had a mean self-esteem score of 30 points, indicating that, overall, students showed high self-esteem. Of all participants, 52.5% were classified as having high self-esteem, 28.5% as moderate, and 19.0% as low.

Students' perceptions of PBL varied by self-esteem level. Those with high self-esteem enjoyed PBL more than those with moderate self-esteem (4.39 ± 0.70 vs. 3.88 ± 0.91; p = 0.0020). They were also more likely to agree that the sessions were well organized and effective than students with moderate or low self-esteem (4.17 ± 0.66 vs. 3.83 ± 0.87 vs. 3.81 ± 1.02; p = 0.0486). High self-esteem students reported a better understanding of the course lectures after the PBL sessions than those with moderate or low self-esteem (4.45 ± 0.54 vs. 4.05 ± 0.71 vs. 4.08 ± 0.93; p = 0.0092). They also felt more encouraged to give and receive feedback than students with moderate self-esteem (4.34 ± 0.62 vs. 3.95 ± 0.81; p = 0.0143). Finally, they more strongly believed that participating in the sessions increased their confidence and problem-solving ability compared with students with moderate and low self-esteem (4.10 ± 0.63 vs. 3.65 ± 1.00 vs. 3.58 ± 1.17; p = 0.0271).

Self-esteem levels varied by sex and age. Among women, 21.7% had low self-esteem, 28.3% moderate, and 50.0% high. Among men, 13.3% had low, 28.9% moderate, and 57.8% high self-esteem, indicating a higher concentration of high scores in this group. Among those up to 21 years old, 19.8% had low self-esteem, 30.2% moderate, and 50.0% high. Among students older than 21, a smaller share had low self-esteem (17.0%), and most had high self-esteem (58.6%), while 24.4% had moderate self-esteem.

4.4.7 PBL perceptions by gender

Men reported feeling more encouraged than women to define learning objectives (4.44 ± 0.76 vs. 4.20 ± 0.44; p = 0.0048) and to summarize what they learned in their own words (4.31 ± 0.70 vs. 4.08 ± 0.40; p = 0.0292). The same pattern appeared for confidence in solving real-world problems (4.13 ± 0.92 vs. 3.74 ± 0.80; p = 0.0204) and for perceiving a link between the problems and their prior knowledge (3.87 ± 0.97 vs. 3.47 ± 0.89; p = 0.0234).

Men agreed more strongly than women that the PBL sessions improved their understanding of the theoretical lectures (4.49 ± 0.76 vs. 4.15 ± 0.50; p = 0.0022). They were also more favorable to continuing the use of PBL in the course (4.76 ± 0.43 vs. 4.28 ± 0.58; p < 0.0001) and rated the sessions as more realistic and closely aligned with practical situations than women did (4.67 ± 0.64 vs. 4.26 ± 0.53; p < 0.0001).

Men reported greater enjoyment of the methodology than women (4.51 ± 0.66 vs. 4.11 ± 0.68; p = 0.0095) and a stronger preference for it over the traditional method (4.38 ± 0.83 vs. 3.86 ± 0.88; p = 0.0059). They were also more likely to agree that PBL should replace the conventional method (3.62 ± 1.21 vs. 3.16 ± 0.96; p = 0.0375), to view PBL as relevant to their

field of study (4.62 ± 0.58 vs. 3.95 ± 0.63; $p < 0.0001$), to consider the tutorial group important (4.18 ± 0.68 vs. 3.82 ± 0.61; $p = 0.0273$), and to feel that PBL enhanced their ability to solve real-world problems (4.42 ± 0.54 vs. 4.13 ± 0.55; $p = 0.0348$). Overall, men rated PBL slightly higher than women, although both genders evaluated it positively.

4.4.8 Thematic analysis

Responses to the open-ended questions were largely positive about PBL, emphasizing its role in stimulating knowledge construction and strengthening professional skills. Students suggested increasing the time devoted to problem-discussion sessions to further improve the approach (Table 13).

Table 13 – Summary of themes, codes, and quotes reported by students.

(Continue)

Core themes	Sub themes	Frequency	Sample quotations
Overall satisfaction with PBL	General positive impressions	70	*"I really enjoyed the PBL methodology [...]."*
	Satisfaction with PBL as a teaching method	24	*"I was completely satisfied, as it was a more effective way of learning than traditional lectures."*
Perceived learning	Effective Learning	19	*"[...]I gained a better understanding of the topics."*
	Increased knowledge	14	*"[...]It encouraged me to seek more knowledge [...]."*
	Improved retention of course content	3	*"PBL helped me retain the material better than the lecture-based method."*
	More self-directed study	2	*"PBL encouraged me to study outside the classroom."*
Development of soft skills	Appreciation of group work	16	*"I enjoyed PBL, it was a different moment where I could communicate with other classmates [...]."*
	Improved communication skills	4	*"[...]It helped me overcome my fear of presenting and interacting with others."*

(Conclusion)

	Improved interpersonal skills	1	*"[...]It stimulated my creativity and self-confidence."*
Development of professional skills	Improved real-world problem solving	28	*"It enhanced my ability to solve problems."*
	Better application of theory to practice	3	*"[...] I was able to apply the knowledge acquired in the theoretical classes during the PBL sessions."*
Suggestions for Methodology Improvement	Longer time for group discussion	8	*"Increase the discussion time between groups [...]."*
	More opportunities to discuss outside class	7	*"[...]I would like to have the freedom to discuss with group members outside of class."*
	More flexible group formation	5	*"I would like the tutor to allow students to choose their groups [...]."*
	Clearer and more detailed problem statements	4	*"There should be more details in the problems."*
	More PBL sessions throughout the course	3	*"I believe there could be more PBL sessions [...]"*

Source: own elaboration.

* Ellipses in parentheses indicate text omitted for brevity.

4.5 DISCUSSION

4.5.1 General discussion

PBL had a positive effect on Beekeeping students' perception of their learning, and they generally reported no difficulty learning through this method. Most students enjoyed PBL and were highly satisfied with it. Open-ended responses supported this finding, with 94 comments expressing overall satisfaction. This satisfaction may be linked to the perception that PBL

promotes more effective learning (Trullàs *et al*., 2022), as one student noted: *"...I gained a better understanding of the topics*". Similar results were reported at a university in Ghana, where 64.0% of 1,504 students were satisfied with PBL (Okyere *et al*., 2023). This high level of satisfaction supports the potential of PBL as a pedagogical strategy in Beekeping education, since student satisfaction is associated with learning quality, engagement, and academic success (Muñoz Alvarez *et al*., 2025).

Most students wanted PBL to continue in the course, but did not want it to completely replace the traditional method. Forest Entomology students at the same university had a similar perception (Favalessa *et al*. 2026). The effectiveness of PBL does not mean that it should fully replace traditional strategies. Rather, it should be integrated with them in a balanced way. This combined approach seems appropriate for Beekeeping education. Lectures can provide the conceptual foundation, while PBL encourages active and autonomous application of this knowledge (Tang *et al*., 2020). Using PBL alongside lectures may improve teaching effectiveness and increase student acceptance (Tortorella; Cauchick-Miguel, 2018).

Beekeeping students' preference for a hybrid model, rather than an exclusively PBL-based model, may be associated with their familiarity with traditional teaching and fear of change (Srivastava; Scott, 2025). Thus, when introducing a new teaching approach that is unfamiliar to most students, it is not advisable to fully replace lectures. A gradual implementation of PBL sessions across the course allows students to become familiar with the method, reduces resistance, and promotes greater engagement.

Beekeeping students over 21 years old viewed PBL as more relevant to their education than younger students did. This difference may relate to the greater self-regulation needed for autonomous learning. Self-regulation tends to increase with academic maturity, and older Beekeeping students may have higher levels of this skill, which supports self-directed learning (Bittner; Stamov Roßnagel; Staudinger, 2022). As a result, students over 21 were likely better prepared to meet the demands of PBL, such as autonomy, planning, and teamwork, and therefore perceived the method as more useful and better aligned with their professional development.

Students reported only a moderate connection between the proposed problems and their prior knowledge. This was expected, as most respondents were in their second semester and had limited background in the field and little professional experience, which restricts their ability to make deeper links between the problems and more consolidated content (Dörrenbächer-Ulrich; Dilhuit; Perels, 2024). Introducing active methodologies from the early semesters is important. Doing so can gradually prepare students to engage with more complex

content and develop interdisciplinary thinking. Evidence from a Paramedical Biosciences program in Australia shows that combining active learning strategies can improve first-year students' academic performance (Sinnayah *et al*., 2019), supporting the idea that adopting these methodologies early in training can enhance learning even when students have limited prior knowledge.

Beekeeping students reported that PBL sessions improved their ability to solve real-world problems. This may have strengthened their technical skills, critical thinking, and social awareness, as also observed among Agro-Food and Rural Environment Engineering students in Spain (Revilla-Cuesta *et al*., 2023). PBL promotes dynamic and context-based learning by encouraging investigation, hypothesis formulation, peer discussion, integration of information and concepts, and evidence-based decision-making (Broseghini *et al*., 2024). Thus, PBL in Beekeeping may help form professionals who think critically and can apply their knowledge to solve real-world challenges.

Students moderately agreed that the tutorial group contributed to solving the problems, but indicated that the main difficulties were communication and collective work. This suggests that Beekeeping students were not used to working collaboratively. Communication problems among peers have also been reported in a technical physics course in Chile that used PBL (Muñoz Alvarez *et al*., 2025). Activities that require intense interaction and negotiation within groups can cause stress and resistance to the method (Broseghini *et al*., 2024). Although collaboration is central to PBL, it poses a challenge for Beekeeping students encountering the method for the first time, likely because many have not yet developed cooperation, communication, and group task-management skills. At the same time, the difficulties they report suggest that these skills are beginning to develop through PBL (Broseghini *et al*., 2024). For this reason, the implementation of PBL should include an adaptation period, such as the gradual introduction of PBL across the semester, with sessions that become progressively more complex. This could help students to become familiar with the roles, stages, and expectations of the method. In addition, strategies to support group dynamics, such as tutor mediation and moments for collective feedback, are necessary.

4.5.2 Influence of sociodemographic and psychological factors on PBL experiences

Students generally felt more confident about solving real-world problems after the implementation of PBL. This suggests that PBL may have had a positive effect on their self-confidence compared to traditional teaching (Muhtadi; Hukom 2025). Beekeeping students

with higher self-esteem perceived the greatest gain in confidence, compared to those with medium or low self-esteem. Students with high self-esteem are more likely to trust their abilities, seek solutions proactively, persist in the face of difficulties, and experience less anxiety and stress (Ni *et al*., 2025). They also reported enjoying PBL more than their peers with medium or low self-esteem. By contrast, students with low self-esteem may have faced more barriers to fully engaging with PBL, as negative emotions can hinder adaptation to new academic environments and activities (Ni *et al*., 2025).

Beekeeping students aged 17 to 21 showed a higher proportion of low or medium self-esteem (50.0%) than students over 21 years old (41.5%). Younger students, who are still adapting to higher education, may face greater challenges that shape their perception of and engagement with PBL. The transition from high school to university demands more autonomy, organization, and interaction with new peers, which can lead to insecurity, loneliness, and lower self-esteem, especially in the first year (Dörrenbächer-Ulrich; Dilhuit; Perels, 2024).

Men had higher mean scores on some items, even though they were a minority in the sample. This suggests that the associations between sex and PBL perceptions reflect real differences in response patterns rather than bias from sample composition. Men perceived PBL as more stimulating and more closely aligned with their professional training than women did. One possible explanation is that men tend to report higher academic self-efficacy than women, that is, a stronger belief in their ability to learn or perform academic tasks (Huang, 2013). Higher self-efficacy may promote more positive experiences with methods that demand autonomy and active participation, such as PBL (Lesperance *et al*., 2022). In a study of Statistics students in Spain, older men also expressed greater appreciation for the usefulness of the PBL problems, suggesting that both age and gender can shape students' perceptions of this method *(Muerza et al*., 2024).

Men reported lower rates of low self-esteem (13.3%) than women (21.7%). This difference is relevant because self-esteem can influence the perception of self-efficacy (Lesperance *et al*., 2022) and, in turn, shape students' experiences with PBL. It is therefore likely that women with lower self-esteem, especially those aged 17 to 21 and in the early years of their degree, experienced PBL less positively. These findings highlight the need to consider sociodemographic and psychological factors when implementing PBL, so that the approach can be adapted to different student profiles and used in a more inclusive way. Tutors should be attentive to these dynamics, offering support and gradually encouraging participation from all students, especially those who may feel more insecure in the learning process.

The gender differences in PBL perceptions may reflect social and cultural dynamics (Moraga-Pumarino; Salvo-Garrido; Ortiz-Cea, 2025) and do not necessarily mean that men learned more than women. Gender stereotypes can limit women's self-confidence, reduce their participation, and undermine their sense of competence (Moraga-Pumarino; Salvo-Garrido; Ortiz-Cea, 2025). As a result, women often perceive more barriers and evaluate their abilities more critically, while men tend to overestimate their competence (Sakellariou, 2022). These patterns are especially common in male-dominated fields, such as Beekeeping, Agricultural Sciences, Business, and Engineering (Liu; Jong; Fan, 2024). Male students often report higher confidence in leadership, analytical tasks, and decision-making (Huang, 2013; Viviers; De Villiers; Van der Merwe, 2023), which are central to PBL dynamics, and may therefore perceive the method more positively. Tutors should adopt strategies that promote more equitable participation between genders, ensuring so that all students benefit from active learning. Forming heterogeneous groups and encouraging women's participation can increase engagement and reduce asymmetries during PBL sessions (Aguillon *et al*., 2020).

4.5.3 Suggestions for improving PBL

Students suggested that the PBL problems should be clearer. One way to address this is to complement the cases with multimedia resources, such as videos, which add visual and auditory support and accommodate different learning styles. Among Statistics students at the University of Zaragoza, integrating videos helped them understand concepts and improved their ability to present and explain content to peers in PBL activities (Muerza *et al*., 2024). Multimedia-supported problems could be more engaging and easier to grasp, fostering a more immersive and inclusive learning environment.

Students also recommended extending the duration of PBL sessions. One hour per session may have been insufficient, and limited time is a known barrier to PBL *(Komuhangi et al*., 2025). In this study, PBL sessions were conducted in two separate groups with consecutive schedules. A possible way to address the time constraint would be to combine the groups. This would double the time available for each PBL session but would also require more evaluators and tutors, who are not always available.

Students also suggested the possibility of discussing the problems outside the classroom. This view may be linked to their first contact with PBL and an incomplete understanding of its principles. In the opening session, the tutor explains that the materials gathered during self-study should not be shared before the closing session. This guideline prevents all students from

relying on the same sources, preserves diversity of ideas and solution paths, and emphasizes that a single problem can have multiple valid answers.

Students also suggested to choose their own work groups. However, one goal of PBL is to prepare students for collaborative work in real-world settings, where colleagues are not self-selected. For this reason, the tutor forms the groups, ensuring heterogeneity among members, which enriches discussion and collective learning.

4.5.4 Limitations and future directions

Despite the contributions to Beekeeping education, this study has some limitations. Although we collected 137 questionnaires, this number does not represent all Beekeeping students in Animal Science programs in Brazil, which restricts the generalizability of the findings. The results may also reflect specific features of the university or cultural characteristics of the region in which the study was conducted. The use of self-report questionnaires is another limitation, as the data depend on students' perceptions. Anonymous responses and Likert scales help reduce bias, but subjectivity cannot be fully eliminated. Future studies should combine questionnaires with interviews and classroom observations to provide a more robust analysis of student satisfaction, and a broader understanding of how the method is received. Finally, perceived satisfaction does not necessarily correspond to academic performance. Studies comparing objective outcomes between control groups and PBL groups are needed to assess the impact of PBL on students' learning and performance.

4.6 CONCLUSION

Students were satisfied with PBL. Most reported positive experiences and wished to continue using the method in the course, but satisfaction levels varied. This variation suggests that sociodemographic and psychological factors shape how students perceive PBL and should be considered when planning courses or modules that use it. Understanding the student profile is essential for designing interventions that make the methodology meaningful for learning. When well implemented, PBL can not only deepen students' understanding of Beekeeping concepts but also build confidence and develop skills that are applicable to real-world professional challenges.

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CAPÍTULO 5 – CONSIDERAÇÕES FINAIS

Esta pesquisa teve como objetivo analisar a satisfação dos estudantes de Apicultura e Entomologia Florestal com a metodologia PBL. A PBL é uma abordagem viável para aplicação em disciplinas do curso de Engenharia Florestal, sendo percebida de forma positiva pelos estudantes. A metodologia favoreceu o engajamento, a autonomia e a participação ativa dos discentes, além de contribuir para o desenvolvimento de competências técnicas e interpessoais relevantes para a formação profissional. A percepção e a satisfação com a PBL não se manifestam de maneira homogênea entre os alunos, uma vez que são influenciadas pelo contexto da turma, pelo período do curso, pelo nível de maturidade acadêmica e por aspectos psicossociais, como gênero e autoestima. Assim, tais fatores devem ser considerados pelos tutores no planejamento e na condução das sessões de PBL.

A PBL é um método de ensino que aproxima a universidade das demandas do setor produtivo, mas seu potencial só se efetiva quando adaptada estrategicamente às particularidades de cada etapa da formação. Sua implementação bem-sucedida requer planejamento pedagógico que considere os diferentes perfis discentes. Turmas em fases iniciais demandam maior acompanhamento do tutor, problemas mais detalhados e estratégias que favoreçam o desenvolvimento gradual do trabalho colaborativo, enquanto turmas em períodos mais avançados do curso se beneficiam de problemas mais complexos, interdisciplinares e próximos da realidade profissional.

Os resultados desta pesquisa apresentam implicações práticas para docentes do curso de Engenharia Florestal interessados em adotar a metodologia PBL. Para que essa abordagem seja implementada de forma efetiva em disciplinas das Ciências Agrárias, é importante que as instituições de ensino ofereçam apoio institucional e promovam políticas de formação continuada docente, criando condições para que a PBL seja aplicada de maneira consistente, contextualizada e alinhada às especificidades dos cursos. Do ponto de vista teórico, o estudo evidencia o potencial da PBL no ensino de Apicultura e Entomologia Florestal, um campo ainda pouco explorado por metodologias ativas, demonstrando que a abordagem contribui não apenas para o domínio de conteúdos técnicos, mas também para o desenvolvimento de competências interpessoais essenciais à formação profissional.

APÊNDICE A – CASOS ABORDADOS DURANTES AS SESSÕES PBL E BAREMA DE AVALIAÇÃO

Applied cases in Forest Entomology

Problem #1

A forestry company certified by FSC, located in southeastern Brazil, has hired you to address an issue in their operations. The company runs a forest nursery capable of producing 30 million seedlings annually. Recently, they noticed the formation of galls—swellings on the main leaf veins, petioles, or young branches—appearing on Eucalyptus camaldulensis x E. grandis seedlings inside the greenhouse. Upon inspection, 430 out of 500 seedlings evaluated showed these symptoms. However, no signs of galls have been observed in the field. The company's management is asking you to identify the pest responsible and provide a solution, as the ongoing pest issue could jeopardize the seedling planting phase if left untreated.

Problem #2

A man owns a restored, like-new NEO GEO MVS arcade machine with a cabinet made entirely of MDP, valued at around $400. Recently, he noticed fecal "pellets," identified as termite droppings, and the cabinet's structure has started showing signs of termite damage. He is seeking a solution to protect the valuable original electronic components and the wooden cabinet. Additionally, he is curious about the species of termite responsible for the damage, how to effectively control them, and an estimate of the cost for resolving this issue.

Applied cases in Beekeeping

Problem #1

The Santa Maria farm hotel receives tourists year-round and offers several attractions and activities, such as swimming pools, water sports, soccer fields, and more. After the number of visitors dropped during the COVID-19 pandemic, the hotel owner decided to start beekeeping and sell bee products in the farm's gift shop to help increase revenue. Your group has been hired to manage the hotel's beekeeping operation. Your first task is to decide where on the farm the apiary should be installed (the owner wants to start with 10 hives). She also wants to know how she will obtain bees for these 10 hives. In addition to the hives, workers, hive stands, site cleaning, and equipment for honey extraction and processing will be required. The owner is offering you R$ 3,000 to purchase the equipment and all items needed for managing the apiary; however, she requests that you send her a list of this equipment along with the average price of each item.

Problem #2

You still provide consulting services for Hotel Santa Maria. The apiary, with 10 hives, and the bees have started producing. Near it, there is a strawberry plantation where productivity increased by 20% in the last year, coincidentally right after the installation of the apiary. You show this result to your boss in an attempt to increase the number of hives. However, she disagrees with you and insists that the increase in productivity was due to a higher volume of rainfall. To prove your point of view and change the

owner's mind, you will prepare a small experiment with the strawberries and the bees, detailing the entire methodology and expected results.

PBL Rubric

Criteria	Needs Improvement (0-1)	Meets Some Requirements (2-3)	Meets Most Requirements (3-4)	Meets All Requirements (4-5)	Points
Problem Definition	The student did not identify the problem.	The student failed to adequately define the problem.	The student adequately defined the problem.	The student clearly defined the problem and identified underlying issues.	
Collection and Analysis of Information	The student did not collect viable information.	The student collected inadequate information for meaningful analysis.	The student collected adequate information and performed basic analyses.	The student collected information from multiple sources and analyzed it in depth.	
Engagement	Did not contribute to the activity by offering ideas or asking questions.	Contributed to the activity by offering ideas and asking questions only once.	Proactively contributed to the activity by offering ideas and asking one or two questions.	Proactively contributed to the activity by offering multiple ideas and asking more than two questions.	
Teamwork	The student never responded to peers' questions, ideas, or opinions. Did not listen to others, did not cooperate, got distracted, and was disrespectful (e.g., yelling).	The student rarely responded to peers' questions, ideas, or opinions. Mostly did not listen, cooperated briefly, and was occasionally disrespectful (e.g., sarcasm or insinuations).	The student generally responded to peers' questions, ideas, or opinions. Listened to others, cooperated, stayed focused, and treated peers respectfully.	The student responded to most peers' questions, ideas, or opinions. Listened, encouraged peers, cooperated, stayed focused, and treated peers with courtesy and civility.	
				Final Score (Max: 20 points)	

APÊNDICE B – INSTRUMENTO DE COLETA DOS DADOS

SECTION A – GENERAL DATA

1- What is your age?

☐ Between17 and 21 years old

☐ Between 22 and 26 years old

☐ Between 27 and 31years old

☐ Over 31 years old

2- What is your gender?

☐ Female ☐ Male

3- Where did you attend high school?

☐ Public school

☐ Private school

☐ Partly in public and partly in private school

4- What is your current academic semester? _____

5- What is your current GSG (Global Semester Grade – GSG)?_____

_____

Rosenberg Self-Esteem Scale

Statement	Strongly agree	Agree	Disagree	Strongly disagree
I feel that I'm a person of worth, equal to others.	☐	☐	☐	☐
I feel that I have a number of good qualities.	☐	☐	☐	☐
All in all, I feel that I am a failure.	☐	☐	☐	☐
I am able to do things as well as most other people.	☐	☐	☐	☐
I feel that I do not have much to be proud of.	☐	☐	☐	☐
I take a positive attitude toward myself.	☐	☐	☐	☐
On the whole, I am satisfied with myself.	☐	☐	☐	☐
I wish I could have more respect for myself.	☐	☐	☐	☐
At times, I feel useless or incapable.	☐	☐	☐	☐
At times, I think I am no good at all.	☐	☐	☐	☐

SECTION B – LEARNING/SATISFACTION WITH PBL METHODOLOGY

The following questions ask about your learning strategies, study skills, and level of satisfaction with PBL (Problem-Based Learning). There are no right or wrong answers. Please respond to questions 1 through 19 as accurately as possible.

1. I felt encouraged to clearly formulate the learning objectives.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

2. I felt encouraged to summarize what I learned in my own words.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

3. I felt encouraged to integrate concepts across the course content.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

4. I felt encouraged to give and receive feedback during the opening and closing phases of the sessions.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

5. By participating in the PBL sessions, your confidence and ability to solve real-world problems improved.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

6. The problems presented were related to my prior knowledge.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

7. The PBL sessions improved my understanding of the lectures taught during this academic semester.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

8. The PBL sessions improved my ability to work in groups.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

9. I felt encouraged to regularly evaluate how the tutorial group members cooperated.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

10. The PBL sessions should be maintained as part of the studied discipline.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

11. The PBL sessions were realistic and reflected real practical situations.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

12. I felt encouraged to apply what I learned to the task/other situations/problems.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

13. The PBL sessions were well-organized and effective.

☐ Strongly Disagree ☐ Discordo parcialmente ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

14. I enjoyed the PBL methodology.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

15. I prefer the PBL methodology to the method currently used.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

16. PBL should replace the conventional study method in this course.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

17. I did not have difficulties learning with the PBL methodology.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

18. The time provided to solve the proposed problem was adequate.

☐ Strongly Agree ☐ Partially agree ☐ Neutral / No Opinion ☐ Disagree ☐ Strongly Disagree

19. The PBL methodology is relevant to my field of study.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

20. The tutorial group was important for solving the problem.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

21. The problems proposed during the PBL sessions improved my ability to solve real-world problems.

☐ Strongly Disagree ☐ Partially Disagree ☐ Neutral / No Opinion ☐ Agree ☐ Strongly Agree

22. What was the biggest difficulty you faced with PBL? (If necessary, select more than one option.)

☐ I did not have any difficulties.
☐ Identifying the problem presented by the tutor.
☐ Communicating with group members.
☐ Planning the solution to the problem collectively.

☐ Finding a solution to the proposed problem.
☐ The short time given to find a solution to the proposed problem.
☐ Other:

_____

_____

_____

_____

23. How many hours, on average, did you spend on self-study per week?

☐ Less than 1 hour.

☐ Between 1 and 2 hours.
☐ Between 2 and 3 hours.
☐ Between 3 and 4 hours.
☐ Between 4 and 5 hours.
☐ More than 5 hours.

SECTION C – SUGGESTIONS FOR IMPROVING PBL

1. What is your overall satisfaction with the adoption of PBL in the Forest Entomology course?

_____

_____

_____

_____

_____

2. Do you have any feedback or suggestions for improving the methodology in this course?

_____

_____

_____

_____

_____

_____

APÊNDICE C – TERMO DE CONSENTIMENTO LIVRE ESCLARECIDO

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Caro participante,

Você foi convidado a participar da pesquisa: "Aprendizagem baseada em problemas (PBL) aplicada em disciplinas de entomologia nos cursos de graduação da Universidade Federal de Minas Gerais", coordenada pelo Prof. Pedro Guilherme Lemes. O objetivo é avaliar a satisfação dos alunos quanto à aprendizagem pela metodologia PBL, por meio da aplicação de atividades de PBL e questionário. Os alunos não serão identificados no questionário para reduzir riscos e resguardar a dignidade da pessoa humana. No entanto, ao lerem os resultados da pesquisa pode ser que se reconheçam em algum contexto. Outro risco é sentirem algum desconforto ou constrangimento, mas a chance disso ocorrer é mínima, já que somente os pesquisadores terão acesso aos dados obtidos. Caso sinta desconforto ao responder alguma pergunta do questionário, poderá deixá-la sem responder, ou desistir, sem qualquer penalidade ou prejuízo a sua pessoa. Os pesquisadores terão cuidado com os dados, que ficarão armazenados em planilhas eletrônicas no computador e os questionários dentro de pasta em armário trancado na universidade. Os formulários eletrônicos e os questionários serão apagados e destruídos dois anos após o término da pesquisa. O participante será beneficiado com o estímulo à autorreflexão sobre a ética, construída na vivência da disciplina. Sua participação na pesquisa é de livre e espontânea vontade. Sua participação não interfere na relação professor-aluno, nem nas notas das avaliações realizadas na disciplina, assim como você tem a liberdade de ser sincero em suas respostas sem sofrer qualquer sanção ou penalidade. A pesquisa seguirá todos os preceitos éticos estabelecidos na Resolução 466/12 e Resolução 510/2016, ambas do Conselho Nacional de Ética em Pesquisa. A pesquisa foi aprovada pela Congregação do Instituto de Ciências Agrárias - UFMG Campus Regional de Montes Claros e pelo Comitê de Ética da UFMG (CEP/UFMG). Você receberá uma via deste Termo. Abaixo estão os contatos do pesquisador principal, para tirar dúvidas, a qualquer momento, sobre o projeto e a sua participação, e do Comitê de Ética, CEP/UFMG, para dúvidas de aspectos éticos. Você assinará este Termo declarando que entendeu as informações da pesquisa, concordando em participar. Desde já, agradecemos a sua colaboração.

_____

Assinatura - Participante

_____

Assinatura - Professor

Comitê de Ética em Pesquisa da UFMG (CEP/UFMG): Av. Antônio Carlos, 6627, Pampulha - Belo Horizonte - MG - CEP 31270-901 Unidade Administrativa II - 2º Andar - Sala: 2005 Telefone: (031) 3409-4592 - E-mail: coep@prpq.ufmg.br. Contato do pesquisador responsável: Pedro Guilherme Lemes. E-mail: pedroglemes@hotmail.com Endereço: Av. Universitária, 1000, B. Universitário, Montes Claros, Minas Gerais, CEP 39404-547.